# Proceedings

of the

# Twenty-fifth

# Indian Science Congress

CALCUTTA, 1938

(SILVER JUBILEE SESSION)

*Published by the Royal Asiatic Society of Bengal,*

1, *Park Street, Calcutta*

1939

# Proceedings of the Twenty-fifth Indian Science Congress

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# Proceedings of the Twenty-fifth Indian Science Congress

## (SILVER JUBILEE SESSION)

## held jointly with

## The British Association for the Advancement of Science

## PART I

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# PROCEEDINGS OF THE TWENTY-FIFTH INDIAN SCIENCE CONGRESS.

## (Silver Jubilee Session.)

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| Dr. G. S. Ghurye .. .. .. | |
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| Mr. T. C. Das .. .. .. | *Past Recorders who are Ordinary Members.* |
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| Dr. D. N. Majumdar .. .. | |

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| Dr. A. N. Puri .. .. .. | *Recorder.* |
| Prof. S. P. Agharkar .. .. | *Sectional Correspondent.* |
| Mr. R. P. Mitra .. .. .. | *Local Sectional Secretary.* |
| Dr. C. N. Acharya .. .. | *Elected Members.* |
| Dr. Amir Ali .. .. .. | |
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| Dr. S. S. Nehru .. .. .. | |
| Mr. A. K. Y. Narayan Aiyer .. .. | |
| Rao Bahadur B. Viswa Nath .. .. | |

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| Mr. Y. D. Wad .. .. .. | |

**10. Medical Research—**

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| Dr. K. V. Krishnan .. .. | *Sectional Correspondent.* |
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**11. Veterinary Research—**

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**12. Physiology—**

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| Prof. H. E. C. Wilson .. .. | *Past Recorders who are Ordinary Members.* |
| Prof. N. M. Basu .. .. .. | |

**13. Psychology—**

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| Mr. H. D. Bhattacharya .. .. | |
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| Prof. N. S. N. Sastry .. .. | |
| Dr. G. Bose .. .. .. | |
| Mr. M. N. Banerjee .. .. | |
| Dr. S. C. Mitra .. .. .. | |
| Mr. J. M. Sen .. .. .. | |
| Mr. D. Ganguly .. .. .. | *Past Recorders who are Ordinary Members.* |
| Miss S. Ghosh .. .. .. | |
| Rev. J. C. Manry .. .. .. | |

## 3. LOCAL RECEPTION COMMITTEE.

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B. M. Sen, Esq., M.A., M.Sc., F.N.I., I.E.S., Principal, Presidency College, College Street, Calcutta.

**HONORARY TREASURER:**

Dr. S. C. Law, M.A., B.L., Ph.D., F.N.I., F.Z.S., M.B.O.U., 50, Kailas Bose Street, Calcutta.

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The Hon. Mr. Syed Nausher Ali.
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H. C. W. Bishop, Esq. (*Balmer Lawrie & Co.*)
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S. M. Bose, Esq. (*Public Service Commission*)
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Dr. Panchanan Chatterjee.
Ashoke Chatterjee, Esq.
N. C. Chatterji, Esq.
A. N. Chaudhuri, Esq.
S. K. Roy Chowdhury, Esq.
P. Ray Choudhuri, Esq. (*Mitters Ltd.*)
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Prof. P. C. Mahalanobis.
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G. L. Mehta, Esq.
Major General P. S. Mills, I.M.S.
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S. N. Mitter, Esq.
J. C. Mookerjee, Esq.
Charles T. Moore, Esq.
Prof. J. N. Mukherjee,
*General Secretary.*
J. N. Mukerji, Esq.
Dr. Bamandas Mukherjee.
S. C. Mukerjee, Esq., I.C.S. (Retd.).
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E. S. Olpadvala, Esq.
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S. C. Roy, Esq.
W. M. Roy, Esq.
Mrs. W. M. Roy.
Kumar D. N. Roy.
Dr. B. C. Roy.
Bonowari Lal Roy, Esq.
The Hon. Mr. N. R. Sarker.
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Dr. A. K. Sen.
Principal J. M. Sen.
Prof. N. N. Sen.

S. P. Sen, Esq.
A. C. Sen, Esq.
S. K. Sen, Esq.
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Dr. A. C. Ukil.
Lt.-Col. E. H. Vere-Hodge, I.M.S.
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J. D. A. Vincent, Esq.
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The Most Rev. Bishop Foss Westcott.
Principal R. Wolfenden.
W. C. Wordsworth, Esq.
Principal B. M. Sen,
*Local Secretary.*
Prof. S. K. Mitra,
*Local Secretary.*

**SPECIAL OFFICERS OF THE LOCAL RECEPTION COMMITTEE:**

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| *Musical Soiree* .. .. .. | Mrs. B. M. Sen.<br>Mr. T. Dey.<br>Mr. K. N. Chatterjee.<br>Dr. Aswini Kumer Chowdury.<br>Mr. Harendra Lal Ghosh. |
| *Pandal, Senate Hall and meeting rooms in Asutosh buildings* .. .. | Mr. Asutosh Mukherji.<br>Mr. Somesh Chandra Choudhury. |
| *Residence—* | |
| (Asutosh Buildings) .. .. | Mr. Sailendra Nath Mitra.<br>Prof. P. C. Mitter.<br>Dr. B. N. Chuckerbutti.<br>Mr. S. K. Acharya. |
| *Reception at Station* .. .. | Prof. P. C. Mitter.<br>Dr. B. N. Chuckerbutti.<br>Mr. Sachindra Nath Banerjee.<br>Mr. J. M. Majumdar.<br>Mr. S. K. Acharya. |
| *Luncheon and Congress dinner* .. | Mr. S. K. Chatterjee.<br>Mr. J. M. Majumdar.<br>Mr. Sachindra Nath Banerjee. |
| *Excursions—* | |
| Bolepur .. .. .. | Principal B. M. Sen. |
| Tatanagar .. .. | Mr. S. Datta. |
| *University Party* .. .. | Dr. P. K. Bose, Mr. B. C. Ray.<br>Mr. Girindra Nath Chakravarti. |
| *Local Secretary's Office* .. .. | Mr. S. Datta.<br>Mr. N. Dasgupta. |
| *Refreshment Rooms—* | |
| General .. .. .. | Dr. S. Datta & Dr. M. Q. Khuda. |
| Indian .. .. .. | Mr. G. P. Majumdar. |
| *Exhibition* .. .. .. | Mr. C. C. Bhattacharya.<br>Mr. N. N. Sen.<br>Mr. N. Neogy.<br>Mr. K. C. Chakravarty. |

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| *Volunteers* .. .. .. | Mr. S. M. Banerji.<br>Mr. P. Dutt.<br>Mr. K. N. Chakravarty. |
| *Lady Volunteers* .. .. | Miss M. Bonnerji.<br>Mr. S. K. Acharya. |
| *Conveyance* .. .. .. | Mr. J. Lahiri.<br>Mr. H. D. Mukherji.<br>Mr. B. C. Das. |
| *Steamer Party* .. .. .. | Dr. J. Ghosh.<br>Mr. G. D. Bhar. |
| *Office* .. .. .. | Mr. C. C. Bhattacharya.<br>Mr. S. K. Mukherji.<br>Mr. S. C. Dhar.<br>Mr. D. P. Bose.<br>Mr. A. Maitra. |
| *Enquiry office* .. .. | Mr. S. N. Das.<br>Mr. S. C. Sen.<br>Mr. H. N. Raha.<br>Mr. S. C. Sen Gupta.<br>Dr. K. C. Kar.<br>Mr. D. Bhaduri.<br>Mr. S. L. Mitra. |
| *Reception Room* .. .. | Mr. N. M. Bose.<br>Dr. S. K. Majumdar. |
| *Popular Evening Lecture* (Senate Hall) | Mr. J. M. Majumdar.<br>Mr. Somesh Ch. Chowdhury. |
| ,, ,, ,, (Ashutosh College) .. | Mr. Mahadev Chakrabarti. |
| ,, ,, ,, (University Institute Hall) .. | Mr. S. N. Bhattacharyya.<br>Mr. Ramdas Mukherjee. |

## 4. GENERAL.

The Indian Science Congress Association attained its Silver Jubilee in 1938 and to celebrate the occasion the twenty-fifth meeting (Silver Jubilee Session) was held as a joint Session of the Indian Science Congress Association and the British Association for the Advancement of Science at Calcutta from January 3rd to 9th, 1938 under the auspices of the University of Calcutta. In addition to the British Association Delegation, a number of eminent foreign scientists attended the meeting at the invitation of the Indian Science Congress Association.

The inaugural meeting was held on Monday, January 3rd, 1938 at 10 A.M. at the University College of Science, Calcutta. The Chairman of the Reception Committee welcomed the delegates in a speech and requested His Excellency the Viceroy to open the Congress. His Excellency opened the Congress with a speech and the President of the Congress delivered his address. The President then read out extracts from the address which the late Lord Rutherford had prepared for the occasion.

The Sectional Presidential Addresses were delivered as follows :—

**Tuesday, January 4th:** 9-30 A.M., Botany; 10-30 A.M., Physiology; 11-30 A.M., Agriculture.

**Wednesday, January 5th:** 9-30 A.M., Medical Research and Psychology; 10-30 A.M., Mathematics and Physics; 11-30 A.M., Geography and Geodesy, Entomology.

**Friday, January 7th:** 9-30 A.M., Zoology; 10-30 A.M., Veterinary Research; 11-30 A.M., Chemistry.

**Saturday, January 8th:** 10-30 A.M., Geology; 11-30 A.M., Anthropology.

Symposia and Joint Meetings of Sections were held as follows :—

**Tuesday, January 4th:** 10-30 A.M.–12 noon, Discussion on 'Animal ecology in relation to India', Section of Zoology; 1-30 P.M.–3 P.M., (1) Discussion on 'Blood groupings and racial classification', Section of Anthropology; (2) Joint Meeting of the Sections of Entomology and Agriculture to discuss 'Biological control of insect

pests'; (3) Joint Meeting of the Sections of Geology and Botany to discuss 'Discrepancies between the chronological testimony of fossil plants and animals'; 1-30 P.M.–4 P.M., (1) Joint Meeting of the Sections of Mathematics and Physics and Chemistry, held in co-operation with the Indian Physical Society to discuss 'Recent advances in molecular structure from the physico-chemical standpoint'; (2) Joint Meeting of the Sections of Medical Research, Veterinary Research and Physiology to discuss 'Animal and their diseases in relation to man'; (3) Joint Meeting of the Sections of Botany and Chemistry, held in co-operation with the Society of Biological Chemists, India, to discuss 'The absorption of salts by plants'.

**Wednesday, January 5th:** 9-30 A.M.–11 A.M., (1) Discussion on 'Algal problems peculiar to the tropics, with special reference to India', Section of Botany; (2) Discussion on 'The place of systematics and morphology in the study of the living animal', Section of Zoology; 9-30 A.M.–11-30 A.M., Discussion on 'The teaching of geography in India', Section of Geography and Geodesy; 11 A.M.–12-30 P.M., Discussion on 'Recent advances in the structure of alkaloids', Section of Chemistry held in co-operation with the Indian Chemical Society; 11-30 A.M.–12-30 P.M., Discussion on 'Immunity in protozoal infections', Section of Medical Research; 1-30 P.M.–3 P.M., Discussion on 'The dissemination of cereal rusts in India', Section of Botany; 1-30 P.M.–4 P.M., Joint Meeting of the Sections of Zoology, Medical Research, Veterinary Research, Entomology and Agriculture to discuss 'The relation of Zoology to Medicine, Veterinary Science and Agriculture'; 2 P.M.–4 P.M., (1) Discussion on 'The importance of Anthropological studies for India', Section of Anthropology; (2) Discussion on 'The significance of boundary faults in the Sub-Himalayas', Section of Geology.

**Friday, January 7th:** 9-30 A.M.–12-30 P.M., Discussion on 'Contributions of abnormal psychology to normal psychology', Section of Psychology; 10-30 A.M.–11-30 A.M., Discussion on 'Physiology of the individual in health and disease', Section of Physiology; 11 A.M.–12-30 P.M., (1) Discussion on 'The origin of banded gneisses', Section of Geology; (2) Discussion on 'The position of Entomology in the Indian Universities', Section of Zoology and Entomology; 11-30 A.M.–12-30 P.M., Discussion on 'Diet and adaptation to climate', Section of Physiology held in co-operation with the Society of Biological Chemists, India; 1-30 P.M.–4 P.M., (1) Discussion on 'Theoretical statistics', Section of Mathematics and Physics held in co-operation

with the Indian Statistical Conference; (2) Joint Meeting of the Sections of Chemistry, Zoology, Medical Research, Physiology and Agriculture, held in co-operation with the Society of Biological Chemists, India, to discuss 'Colloids in biology, medicine and agriculture'; (3) Discussion on 'Opportunities for Archæological excavations in India', Section of Anthropology.

**Saturday, January 8th**: 9-30 A.M.–11 A.M., Discussion on 'A national herbarium for India', Section of Botany held in co-operation with the Indian Botanical Society; 11 A.M.–12-30 P.M., (1) Discussion on 'Chemistry and industrial development in India', Section of Chemistry held in co-operation with the Indian Chemical Society and the Society of Biological Chemists, India; (2) Discussion on 'The application of statistics in agriculture', Section of Agriculture held in co-operation with the Indian Statistical Conference; 11-30 A.M.–12-30 P.M., Discussion on 'Nutritional diseases in India', Section of Medical Research held in co-operation with the Society of Biological Chemists, India.

**Sunday, January 9th**: 10-30 A.M., Discussion on 'The practicable possibility of breeding immune strains', Section of Veterinary Research; 11-30 A.M.–12-30 P.M., Discussion on 'Pre-Cambrian Sedimentation', Section of Geology; 1-30 P.M.–4 P.M., (1) Joint Meeting of the Sections of Mathematics and Physics, Geology, Geography and Geodesy and Agriculture, held in co-operation with the National Institute of Sciences of India, and the Indian Physical Society to discuss 'River Physics in India'; (2) Joint Meeting of the Sections of Botany, Zoology and Agriculture to discuss 'The species concept in the light of cytology and genetics'.

Popular Lectures were delivered as follows :—

**Monday, January 3rd**: 6-30 P.M., 'The idea of the Nation in Europe' by Prof. H. J. Fleure, F.R.S., Professor of Geography in the University of Manchester.

**Tuesday, January 4th**: 6-30 P.M., (1) 'Rutherford Memorial Lecture' on 'Atoms and Isotopes' by Dr. W. F. Aston, Sc.D., LL.D., F.R.S., Cavendish Laboratory, Cambridge. (2) 'Present position of World Agriculture' by Dr. J. A. Venn, Litt.D., President of Queen's College and Lecturer in the History and Economics of Agriculture in the University of Cambridge.

**Wednesday, January 5th**: 6-30 P.M., (1) 'Nebulæ' by Sir James H. Jeans, D.Sc., Sc.D., LL.D., F.R.S.; (2) 'Greek influence on modern politics' by Prof. Ernest

Barker, Litt.D., D.Litt., LL.D., Professor of Political Science in the University of Cambridge.

**Thursday, January 6th**: 6-30 P.M., 'Uncertainty' by Prof. C. G. Darwin, Sc.D., F.R.S., Master of Christ's College, Cambridge.

**Friday, January 7th**: 6-30 P.M., (1) 'The Milky Way and Beyond' by Prof. Sir Arthur Eddington, D.Sc., LL.D., F.R.S., Plumian Professor of Astronomy in the University of Cambridge; (2) 'English Parliamentarism' by Prof. Ernest Barker, Litt.D., D.Litt., LL.D., Professor of Political Science in the University of Cambridge.

**Saturday, January 8th**: 6-30 P.M., 'The Biology of Death' by Prof. F. A. E. Crew, M.D., D.Sc., Ph.D., Professor and Director of the Institute of Animal Genetics in the University of Edinburgh.

The following Functions and Entertainments were held in honour of the Members of the Indian Science Congress:—

**Sunday, January 2nd**: 6–8 P.M., Theatrical arrangement by the Calcutta University Institute.

**Monday, January 3rd**: 10 P.M., Bratachari Demonstration (G. S. Dutt, Esq., Founder-President).

**Tuesday, January 4th**: 12-30 P.M., Luncheon by the Indian Society of Soil Science to Soil Science delegates at the Great Eastern Hotel; 4-30 P.M., Civic Reception by the Corporation of Calcutta; 8-45 P.M. (for 9 P.M.) Cambridge University Dinner.

**Wednesday, January 5th**: 12-30 P.M., Luncheon by the Indian Chemical Society at the Great Eastern Hotel; 12-45 P.M., Luncheon by the Physiological Society of India to the Physiology delegates at the Lower House, United Service Club; 4-30 P.M.–6 P.M., Afternoon Party by the Bengal Chemical and Pharmaceutical Works at Manicktala.

**Thursday, January 6th**: 11 A.M.–12-30 P.M., Conversazione at the Botany Laboratory; 1 P.M., Luncheon by the Botanical Society of Bengal and the Botany Department, Calcutta University, at the Grand Hotel.

**Friday, January 7th**: 12-30 P.M., Luncheon by the Department of Psychology and its ex-students to the members of the Psychology Section, at the Psychology Laboratory, University College of Science; 4 P.M., Afternoon Party at Government House; 9-30 P.M., Musical Soiree, First Empire Theatre, 4, Chowringhee Place.

**Saturday, January 8th:** 12-30 P.M., Luncheon by the Geological, Mining and Metallurgical Society of India, at the Great Eastern Hotel; 5 P.M., Afternoon Party by the Bengal Immunity at their Laboratory, Baranagore; 8-15 P.M. (for 8-30 P.M.), Science Congress Dinner.

**Sunday, January 9th:** 4-30 P.M.–6-30 P.M., Farewell Party by the University of Calcutta.

The following Visits and Excursions were arranged for Members of the Indian Science Congress Association :—

**Monday, January 3rd :** 2 P.M.–5-30 P.M., River Trip on the Hooghly. The Local Reception Committee were 'At Home' on board the steamers. Two steamers left from Outram Ghat and one from Jagannath Ghat at 2 P.M.

**Wednesday, January 5th:** 1-30 P.M.–4 P.M., Geography Sectional Excursion to the Salt Lakes; 2-30 P.M.–4 P.M., (1) Excursion of the Medical Section to the All-India Institute of Hygiene and Public Health, the Calcutta School of Tropical Medicine, and the Calcutta Medical College; (2) Excursion of the Physiology Section to the All-India Institute of Hygiene and Public Health, the Calcutta School of Tropical Medicine, and the Calcutta Medical College.

**Thursday, January 6th:** (*a*) *Whole day excursions*; (1) Excursions to Tatanagar and Bolepur. Parties left Calcutta on the evening of January 5th, and arrived back on the early morning of January 7th.

(*b*) *Half day excursions*; Excursions to the Botanical Gardens (150th Anniversary at 3-30 P.M.); visit to a film studio; visit to the Calcutta Broadcasting Station; visit to the India Electric Works, Ltd., and several other places.

**Friday, January 7th:** 1-30 P.M.–4 P.M., (1) Excursion of the Geology Section to the Geological Survey Office, and to the Rock, Mineral, and Fossil galleries in the Indian Museum; (2) Entomology Sectional Excursion to the Salt Lakes; 1-30 P.M.—3 P.M., Excursion of the Psychology Section to the Psychology Laboratory; 2-30 P.M.–3-30 P.M., Excursion of the Botany Section to the Bose Institute.

**Sunday, January 9th:** 1-30 P.M.–4 P.M., (1) Medical Sectional Excursion to the Chittaranjan Seva Sadan, and the Jadabpur Tuberculosis Hospital; (2) Excursion of the Physiology Section to the Bose Institute, and Dr. S. C. Law's Aviary; (3) Excursion of the Veterinary Section to the Bengal Veterinary College, Belgachia.

THE SECTIONAL COMMITTEES met at (1) 12 noon on Monday, January 3rd; (2) 9 A.M. on Tuesday, January 4th; (3) 9 A.M. on Wednesday, January 5th; (4) 9 A.M. on Saturday, January 8th; (5) 9 A.M. on Sunday, January 9th.

THE COUNCIL met at 7-45 P.M., on Monday, January 3rd, 1938.

THE EXECUTIVE COMMITTEE met at 1-30 P.M.–3 P.M., on Wednesday, January 5th, 1938.

THE GENERAL COMMITTEE met at 2 P.M.–3 P.M., on Saturday, January 8th, 1938.

The following Scientific Societies held their Annual Meetings during the Silver Jubilee Session of the Congress:—

1. The Annual Meeting of the Society of Biological Chemists, India, held at 3 P.M. on Tuesday, January 4, 1938.
2. The Annual Meeting of the Indian Anthropological Institute, held at 3 P.M. on Tuesday, January 4, 1938.
3. The Annual Meeting of the Indian Society of Soil Science, held at 3 P.M. on Tuesday, January 4, 1938.
4. The Annual Meeting of the Physiological Society of India, held at 1-30 P.M. on Wednesday, January 5, 1938.
5. The Annual Meeting of the Institute of Chemistry of Great Britain and Ireland (Indian Section), held at 1-30 P.M. on Wednesday, January 5, 1938.
6. The Annual Meeting of the Indian Chemical Society, held at 3 P.M. on Wednesday, January 5, 1938.
7. The Annual Meeting of the Indian Physical Society, held at 3 P.M. on Wednesday, January 5, 1938.
8. The Annual Meeting of the Indian Botanical Society held at 9-30 A.M. on Thursday, January 6, 1938.
9. The Annual Meeting of the Indian Psychological Association held at 3 P.M. on Friday, January 7, 1938.
10. The Annual Meeting of the National Institute of Sciences of India held at 3 P.M. on Saturday, January 8, 1938.
11. The Annual Meeting of the Institution of Chemists held at 1-30 P.M. on Sunday, January 9, 1938.

2. The Indian Society of Pathology and Microbiology was formally inaugurated with a provisional Executive Committee of which Sir U. N. Brahmachari was elected President, Dr. A. K. Sen—Treasurer, Dr. H. Ghosh—Secretary, and Dr. B. P. Tribedi—Joint Secretary.

The following were appointed as Regional Correspondents of the Society:—

Dr. Biswanath, Lahore.
Dr. C. C. Basu, Calcutta.
Capt. S. C. Dutta, Muktesar.
Dr. Hyder Ali Khan, Hyderabad (Deccan).
Dr. S. H. Gokhale, Indore.
Dr. V. R. Khanolkar, Parel, Bombay.
Major C. L. Pasricha, Calcutta.
Dr. S. M. Joshi, Kasauli.
Dr. T. S. Tirumurthi, Madras.

## 5. OPENING PROCEEDINGS.

The twenty-fifth meeting (Silver Jubilee Session) of the Indian Science Congress was opened on Monday, January 3rd, 1938 at 10 A.M. by His Excellency the Most Honourable Lord Victor Alexander John Hope, K.T., P.C., G.M.S.I., G.M.I.E., O.B.E., D.L., T.D., the Marquess of Linlithgow, Viceroy and Governor-General of India, at the University College of Science, Calcutta, in the presence of His Excellency the Hon'ble Lord Cecil Marcus Knatchbull-Hugessen, G.C.I.E., M.C., Baron Brabourne, Governor of Bengal and a large gathering of delegates, members and visitors. Seats were specially reserved for the President, Past Presidents, Sectional Presidents, the Chief Minister and Hon'ble Ministers of the Government of Bengal, the Local Secretaries, the General Secretaries, the Managing Secretary, the Senior General Officer, British Association, past Vice-Chancellors of the University, the Chairman, Local Reception Committee and special delegates from Universities and Learned Societies. Mr. Syamaprasad Mookerjee, M.A., B.L., Barrister-at-Law, Vice-Chancellor of the University and Chairman of the Local Reception Committee welcomed the delegates and visitors in a speech as follows:—

" YOUR EXCELLENCIES, LADIES AND GENTLEMEN,

It is my proud privilege to offer a warm welcome to the delegates and other members who have assembled here as representatives of different Universities and various academic bodies from all over the world. We of this University and of this city of Calcutta which witnessed the inauguration of the Indian Science Congress, whose jubilee is being celebrated this year, feel honoured by their presence. We are particularly gratified that this should be a joint-meeting of the Indian Science Congress and the British Association for the Advancement of Science which has done so much for the promotion of scientific knowledge not only in Great Britain but in the British Commonwealth of Nations as well. This joint-meeting which has brought together distinguished men of science from various parts of the world bears testimony to the spirit of fellowship which binds together the scientific workers of the world. It heartens us in these depressing times to think that at least in the realm of science and scholarship there is a unity of outlook and activity which has immense possibilities for moulding the future destiny of the human race.

Two great figures we miss in this gathering to-day. The death of Lord Rutherford and of Sir Jagadis Chandra Bose has created a void which cannot be easily filled, and we consider it

our duty to associate ourselves with the rest of the world in the expression of deep and widespread sorrow with which the news have been universally received. May their careers and achievements serve as an inspiration to all seekers of knowledge and truth for generations to come.

The prevalent idea that Indians are metaphysically-minded and their contributions to positive science are inconsiderable is not based on a full and correct appreciation of historical facts. India has not been a mere dreamer. In her great days she founded colonies, and her missionaries went abroad to spread her culture and her civilization far beyond her bounds. Charak and Susruta, Nagarjuna and Bhaskaracharyya, Aryabhatta and Lilavati and many others who explored the secrets of Nature, made definite contributions to knowledge which succeeding ages have profited by. There has unfortunately been a long period of stagnation; but to-day India is again forging ahead and beginning to contribute to the world's stock of knowledge. Some of her illustrious sons have achieved international fame and eminence. There are many others, less known, who are quietly pursuing their activities in the domain of science, undaunted by adverse circumstances and sustained by remarkable zeal and devotion. It is perhaps a matter of justifiable pride for us to recall that this University was the first in modern India to foster the pursuit of higher scientific knowledge on an organized scale with the help chiefly of Indian scholars, trained here and abroad. We owe it mainly to the vision and constructive ability of Sir Asutosh Mookerjee, its Vice-Chancellor and first President of your Congress, and to the munificence of two of Bengal's illustrious sons, Sir Taraknath Palit and Sir Rash Behary Ghosh. To-day this cultural movement has spread to all parts of India and a steady growth of scientific activities is evident at different centres in the country.

If we are to achieve satisfactory results, it is imperative that larger freedom and ampler facilities should be given to Universities and other bodies interested in higher scientific work. The problem of ordinating their activities and of ensuring unity and harmony among them is an urgent one. The conditions leading to a successful solution of this problem should engage the earnest attention of both scientists and administrators who should possess the right vision and temper.

More and more throughout the world science is being harnessed to the service of man. While specialists must necessarily labour in their chosen fields, the inter-connections between the various branches of science are being increasingly stressed, and the distinction between pure and applied science is becoming less and less marked. While research in the pure sciences without any utilitarian object in view must continue to provide the fundamental basis of discoveries on which the application of science is to rest, the conscious collaboration

between pure and applied science is being steadily fostered everywhere. Let this joint session, historic in its composition, give a clear and definite lead to future activities in India in this direction. India is a country, where the vast body of scientific knowledge already gathered, has not yet been utilized to any appreciable extent for the daily life of man. The practical application of scientific knowledge to problems of industry and agriculture, of sanitation and nutrition, all contributing to the steady increase of the prosperity, joy and happiness of the people, is a question of paramount importance in a country where millions are yet sunk in poverty, disease and ignorance.

The fact that science and technology have been used and are likely to be used in future for destructive purposes has raised doubts in many minds about the utility of science itself. Indeed the harm that has been, can be and is being daily inflicted throughout the world by engines of destruction, scientifically devised, is incalculable. Science is being used for purposes that no one who believes in humanity can contemplate with unconcern. There have been people, honest and well-intentioned, who have been stampeded by this fact into a denial of science itself. A halt has been cried in many quarters to the march of science and technique. Yet it must be clear on a little consideration that the blame must attach not to science but to those men and nations who call themselves civilized, and are shamelessly putting science to an inhuman use. Science, like fire is capable alike of good and of evil and like fire it needs to be used with discretion and care. The good that science has done is obvious and immense. If used exclusively for the good of mankind, it is capable of promoting peace and happiness in this world and of conferring benefits beyond imagination.

What is wrong with the world is not the spirit of science but the moral and social failure of peoples who handle science. Science, in a comprehensive sense, provides us with the material appliances of life. It is the spirit of man who uses them that requires to be educated. The view of science should be supplemented by the vision of beauty and truth. It is of no little significance that this Congress is presided over by one who has proclaimed to us that the world of science reveals the mind of the Supreme One and it is men of his type who should be able to contribute towards the establishment of peace on earth and good will toward men.

In spite of political, national and racial prejudices devotees of knowledge can and should collaborate and become the harbingers of the new era that is to be. Freedom and unfettered devotion to truth must be the supreme condition of their activities. Here in this gathering are assembled men and women from distant parts of the world, who while differing from one another in many respects visibly demonstrate a fraternity that is truly human. When the clouds of distrust

and oppression that hang over the world will lift, things will come out in clear perspective and matters that seem important at the moment will appear inconsequential. Humanity will then proceed in a spirit of common brotherhood to higher and still higher reaches of knowledge and happiness. Let India and her scholars play their part in this noble re-making of man's destiny. Rich with traditions and thoughts and endowed with strength and vitality, India claims the right of being treated as a companion with equal rights in the world's march towards a higher and nobler civilization. Let this international meeting mark a definite stage in this collaboration on a world-wide scale, based on justice and fair play, leading towards the ultimate triumph of truth and of righteousness, of freedom and of peace.

I have now the honour of inviting Your Excellency to open this session of the Congress and extend to it your sympathy and powerful support.''

His Excellency the Viceroy then addressed the meeting as follows:—

"YOUR EXCELLENCIES, SIR JAMES JEANS, MR. VICE-CHANCELLOR, LADIES AND GENTLEMEN,

It was with the utmost pleasure that I accepted the invitation which you so kindly extended to me to open the Jubilee Session of the Indian Science Congress Association. This session is a memorable occasion in the annals of Indian Science, and I would like at the opening of my remarks to extend to the Association my warm congratulations on the successful completion of this stage in its long and useful life. I would like too to extend my congratulations to those responsible for the organization of this Session. They have—and I feel I express the opinion of all present—been peculiarly happy in their choice of Calcutta for the meeting and in their decision, with a view to marking the special character of this Session, to extend invitations to representatives of the British Association, and to scientists from other countries, to join in the discussions and celebrations which are to take place.

The choice of Calcutta as the meeting place is particularly appropriate. For it was here that the first inaugural meeting of the Association was held in 1914, in the rooms of the then Asiatic Society of Bengal, which, if I may quote Sir Ashutosh Mukherjee's words, 'has been throughout its long career the principal source of inspiration in the organization and advancement of scientific research of every description in this country'. I feel that it would not be amiss if I were to express here the deep debt of gratitude which this Association owes to the Royal Asiatic Society of Bengal, which can I think appropriately be described as its foster-parent in its early days and a very benign and helpful relative even to-day. Calcutta, too, is the city with which the name of that distinguished educationist, Sir Ashutosh

Mukherjee, himself the first Chairman of this Association, is associated. I do not think I exaggerate when I say that the beginnings and continued development of the Association are very largely due to his energy and interest, and to the impetus which he imparted to the activities of the Association in its early days.

The visit of the distinguished representatives of the British Association and of scientists from other countries make this Jubilee Session outstanding in the history of the Association. To all our distinguished visitors I extend a very cordial welcome. We in India, if I may say so, consider your visit to this country a very great compliment. Indeed it is more: it is a recognition, as it were, of India's scientific coming of age, and a happy augury for closer co-operation in the domain of science between India and the outside world.

I cannot allow this occasion to pass without expressing our keen regret at the untimely death of Lord Rutherford. He was to have presided over the deliberations of this joint Session. His death means not only the loss of a President who would have left the imprint of his great mind and personality on this Conference, but the loss to the world of perhaps the greatest experimental physicist of modern times. We are fortunate indeed in having Sir James Jeans to take his place. His contributions to astrophysics are world-famous, and his name is familiar to all persons acquainted with the English language through his brilliant exposition of our present knowledge regarding the celestial world.

I would fail in my duty if I did not also mention here the keen regret which we all feel at the death of Sir Jagdish Bose, one of India's greatest scientists, and a man whose work had achieved world-wide recognition. It is especially sad that he did not live to take part in these celebrations to mark the growth of scientific activity in India during the last 25 years—a growth in which he played so important a part. To him belongs the credit of being the first person to initiate scientific research outside the sphere of the Scientific Departments of Government; and I do not think that I should go too far were I to style him the pioneer scientific worker in physics in India.

It is tempting on an occasion such as this to dwell on the personalities and the events which colour and mark the period the completion of which is being celebrated. The history of the Indian Science Congress Association during the last 25 years is rich in both; indeed if one considers the development of world history over those 25 years it would be curious if the Association did not reflect in some degree the movements of those eventful years. But time compels me to refrain from any historical retrospect.

I cannot however pass on without paying a tribute to the success with which the Association has fulfilled the objects for

which it was founded. Since the early seventies of the last century young Indians began to interest themselves in science and to proceed abroad, on what then constituted brave ventures for many of them, to learn science. With the consequent increasing scientific activities in India the want was felt of an institution which would organize meetings of workers in different branches of science and enable them to exchange ideas, to establish those personal contacts which are so helpful in furthering scientific activity, to formulate policies for the furtherance of the cause of science and to bring its needs and services to the notice of those who are in a position to help in the attainment of its objectives. The aims with which the Indian Science Congress Association was founded were three-fold—firstly, to encourage research and to publish the results amongst scientific workers in India; secondly, to give opportunities for personal intercourse and scientific companionship; thirdly, to promote public interest in science. These aims have been magnificently fulfilled. Let me give one example which will demonstrate the progress that has been made. At the first meeting of the Association there were five sections, namely, Chemistry, Physics, Geology, Botany and Ethnology; the membership was 109, and 31 papers were notified for reading. At this year's Conference there are 13 sections, a membership of more than 1,600, and 800 papers have been notified for reading. There are to be 22 discussions within individual sections and 10 joint discussions on programmes which concern more than one section. You will agree, I am sure, that this is a development the significance of which calls for no emphasis.

No one will deny, I think, that the Association, with its annual meetings at various centres throughout India, has done work of the utmost value in the impetus which it has given to scientific research throughout the country, and in the assistance which it has lent, by stimulating close and constant collaboration between scientific workers, in the rationalizing—if I may use a convenient word—of scientific work in India and the elimination of the risks of mutual ignorance and needless duplication of effort.

The Association too has rendered most useful service in bringing Indian scientists before the world outside by creating conditions for systematic presentation of their work. For this India owes the Association no inconsiderable debt of gratitude. India to-day can claim not a few scientists, the originality of whose contributions in different branches of science have won for them international recognition; and I feel myself that the presence of so many eminent scientists from abroad at these celebrations sets the seal of international recognition upon the position to which Science in India has now attained.

We are entitled, I think, to feel that the future of Science in India is full of encouragement. India has demonstrated

beyond question that she possesses men of capacity, with the will to labour; and if in this country we have workers prepared and equipped to take their place amongst those who to-day in every continent are engaged, whether in pure or in applied science, in advancing the frontiers of human knowledge, it is very evident that India affords limitless opportunities for the harnessing of that knowledge for the betterment of mankind. By universal accord, the first and foremost object of our endeavour in the material field must be to better the lot of the agricultural population, to raise the standard of living of the cultivator. Success in that endeavour is the criterion by which all our efforts must ultimately be judged. Mr. President, I have scanned the formidable roll of subjects falling within the several sections into which your Conference has been divided. I find very few of those subjects which by their nature we need regard as being incapable of making a due contribution towards the achievement of that high purpose; and I can imagine no more fascinating challenge to young scientists in this country than the employment of their brains and the application of the latest scientific knowledge to the attempt to solve the manifold problems of material advancement that confront us on every side.

But, encouraging though the prospect may be in theory, India is faced with the same practical difficulties that other countries experience of making provision for research and scientific activities. As regards the division of labour on scientific subjects between various authorities the position in India is, broadly speaking, that the universities devote themselves—and indeed it is fitting that this should be so—to pure science, while research in applied science is carried out in institutions organized for a specific purpose,—the Indian Forest Research Institute at Dehra Dun, the Imperial Agricultural Research Institute at Delhi, the Central Medical Research Institute at Kasauli, the All-India Institute of Hygiene and Public Health at Calcutta,—to name only a few of the more prominent. But the financial burden of this research falls either immediately or in the long run on Government. Research institutions are almost exclusively maintained either by the Central or Provincial Governments; the work of the universities is substantially subsidized by the Governments of the Provinces in which they are situated. It is to my mind an unsatisfactory state of affairs that Government, with the manifold calls on its financial resources, should have to bear the main burden also in this respect. The scope for scientific research, whether pure or applied is practically unlimited; and no small obligation exists, in my judgement, on private munificence to supplement what Governments are now doing in work which Government has for so long so anxiously supported, and to which it continues to-day, directly or indirectly, to contribute on no mean scale. When I make that comment, you will not for a moment think that I in any way underestimate the invalu-

able assistance which has been given by past and present benefactors to specific lines of research and, indeed, to the Jubilee Session which we are opening to-day. My appeal is a wider one. The opportunities of science are great; the field remaining to be explored, the work remaining to be done immense. I am confident that in asking for a still further development of the material and substantial assistance which over so many years have been freely afforded by generous donors, I can rely on a response comparable in some degree with the needs to be met, and, I would say, with the opportunities which offer.

Ladies and Gentlemen, the occasion of this Conference, the presence here to-day of this distinguished gathering, are not merely a recognition of Indian science and scientists. They are more. They constitute, I am satisfied, a manifestation of the interest taken by the intellectual world of the West in the trend of developments in India. Interest from such a source is of inestimable value to India at the present time; it will, I feel, continue to be of value in the future. It is not for me to remind you that India is in a transitional stage; that she is on the threshold of a new era. We may anticipate that the recent political reforms will inevitably find their reflection in an increased determination among Indians that India should continue in increasing degree to make her own individual contribution to world history and world concepts. What will be the nature of that contribution, and what its scale it is difficult to foresee clearly at this period. The history of Indian civilization goes further back than any history of Western countries. The great name of India has throughout that long history at all times been associated with religion, with mysticism, with philosophy and with the arts. Throughout the centuries her economy has been, as indeed it still is and as it is likely to continue to be, fundamentally agricultural, with the simple, patient, methodical and thrifty life for the people which that implies. With the march of years there has come the inevitable impact of the West; and India to-day is engaged on the welding on to her old structures of the newer political and economic forms of the West; on the finding in her intellectual life of a place for the discoveries of science with all their challenge to accepted modes of thought and practice. This is a time therefore when interest, understanding, and sympathy are vital, from those especially who are leaders in science and in those kindred activities which have been so dominant a characteristic of Western development in recent years.

It may be argued that scientists, of all people, are those who can help least in this respect, since scientists speak a universal language, and science is science the world over. But—and I speak with diffidence as a layman—when talking of countries and their civilizations, it is difficult to dissociate a scientist from the background against which he works and from the effect of

his work on the development of his times. The Scientist has his place not only in the world of science but in society as a whole. The backgrounds against which scientists in India and the West pursue their activities are vastly different, and the possible effects on society from the impact of their discoveries on every-day life must inevitably vary. But that difference in no way diminishes the value to us in India of the informed interest, of the advice, and of the wide and varied experience, of those who have seen the possibilities and the limitations of scientific activity in other spheres. Your knowledge, your experience, your very aloofness from the Indian background will impart a special value to any analysis of the problems which confront us here; and to any suggestions which in the light of your deliberations you may feel able to advance as to the directions in which investigation and examination can most fruitfully be pursued. Nor need I emphasize how great a source of encouragement it must be to those who have so unsparingly devoted themselves in this country to the problems which will come before you in your discussions, and to those broad general issues which are, in the scientific field, of such concern to all of us, to feel that in the West there is a growing body of enlightened opinion acquainted with the Indian scene, and understanding in some measure the efforts of India to solve her own problems in her own way.

But the value of the visit will not, I am confident, be felt on one side only. Even the most enthusiastic believer in Western civilization must feel to-day a certain despondency at the apparent failure of the West to dominate its scientific discoveries, and to evolve a form of society in which material progress and spiritual freedom march comfortably together. Perhaps the West will find in India's more general emphasis on simplicity and the ultimate spirituality of things, a more positive example of the truths which the most advanced minds of the West are now discovering. Is it too much to hope that you, Gentlemen, will be a channel through which India will make in increasing degree that contribution to Western and to world thought which those of us who know and love India are confident that she can make in so full a degree."

At the end of His Excellency the Viceroy's speech, the President Sir James Jeans delivered his address.[1] He then read out portions of the address[1] which the late Lord Rutherford had prepared for the occasion. The President then announced messages of congratulation from the following Learned Societies:—

The Royal Asiatic Society of Bengal.
The National Institute of Sciences of India.
The National Academy of Sciences, India.

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[1] Published in Part II of the Proceedings.

The American Association for the Advancement of Science.
The Smithsonian Institution, Washington.
The Prussian Academy of Sciences.
The Kaiser Wilhelm Society for the Advancement of Science.
The Deutsche Akademie, Munich.
The U.S.S.R. Academy of Sciences.

Most of the Indian Scientific and Learned Societies not mentioned above took an active interest in the Jubilee Celebrations, while two special messages were received by cable just before the opening meeting from Lord Rayleigh and Sir Thomas Holland.

His Excellency the Viceroy then conferred the honour of Honorary Silver Jubilee Membership of the Congress upon the following persons:—

Sir James H. Jeans.
Sir P. C. Ray.
Sir Arthur Eddington.
Sir M. Visvesvarya (*in absentio*).
Prof. C. G. Jung.
Sir C. V. Raman (*in absentio*).
Dr. F. W. Aston.
Prof. M. N. Saha.
Prof. L. F. de Beaufort.
Sir Frederick Hobday.
Prof. J. L. Simonsen.
Prof. A. H. R. Buller.

The meeting terminated with votes of thanks to His Excellency the Viceroy and to His Excellency the Governor of Bengal proposed by Professor S. K. Mitra, D.Sc., F.N.I., Local Secretary, and to the Local Reception Committee proposed by W. D. West, Esq., M.A., F.N.I., General Secretary.

## 6. OFFICIAL

### A. THE PARTICIPATION OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AND ARRANGEMENTS FOR IT.

Reference has been made in page 635 of the Proceedings of the Twenty-third (Indore) Meeting to the invitation to the British Association for the Advancement of Science to meet in joint session with the Indian Science Congress Association to celebrate the Silver Jubilee of the Congress. A report regarding the arrangements for the celebration of the Silver Jubilee and for the joint session was submitted to the General Committee at Hyderabad and printed in pp. 604 608 of the Proceedings of the Twenty-fourth (Hyderabad) Meeting.

Further particulars regarding the participation of the British Association in the Silver Jubilee Session and of the arrangements in this connection are given below.

THE PERSONNEL OF THE DELEGATION.

In addition to the persons who were invited as a result of the recommendations of the Sectional Committees invitations were also extended through the British Association to the scientists whose names were suggested at Hyderabad by the Members of the Council and of the General Committee. The British Association has no Medical Section and on the suggestion of the British Association the British Medical Association was approached with a view to ensure the inclusion of representatives of medical men in the delegation. It was mutually agreed that the Indian Science Congress Association would be relieved from the payment of a corresponding quota to the British Association.

To the greatest regret of the scientific world and of the delegation and of the Indian Science Congress Association in particular Professor The Rt. Hon. Lord Rutherford, O.M., F.R.S., the President Elect of the Joint Session passed away on October 19th, 1937. His presence at the meeting and his guidance of its deliberations were eagerly looked forward to in India and his death a few months before the meeting was a great disappointment to all. Sir James H. Jeans, D.Sc., Sc.D., LL.D., F.I.C., F.R.S., Past President of the British Association, was invited through the British Association to take Lord Rutherford's place as President of the Joint Session and fortunately in spite of the shortness of the notice Sir James found it possible to accept the invitation.

A number of the delegates who had accepted the invitation to attend the meeting could not do so. These included Sir Arthur Harden and Sir Gilbert T. Morgan. Ultimately 91 delegates including ladies attended the party.

At Bombay one of the delegates, Dr. A. B. Rendle, F.R.S., who was keeping indifferent health, was advised to discontinue the journey and had to be taken to hospital. He later returned to England, but to the deep regret of all died shortly afterwards. On December 22nd while the party was at Agra Dr. W. W. Vaughan while visiting the Taj Mahal met with an accident which unfortunately later proved fatal. In the darkness he fell from a terrace and broke one of his legs and after a protracted illness died on February 4th, 1938 in the Thomson Hospital at Agra.

A list of the members who finally attended the meeting is given below:

1. Mrs. J. H. Ashworth.
2. Dr. F. W. Aston, Sc.D., D.Sc., LL.D., F.R.S., Fellow of Trinity College, Cambridge.

3. Prof. F. G. Baily, Emeritus Professor of Electrical Engineering, Heriot-Watt College, Edinburgh.
4. Mrs. F. G. Baily.
5. Mr. Harold Baily, M.B.E.
6. Mrs. H. Baily.
7. Prof. E. C. C. Baly, C.B.E., F.R.S., Professor of Inorganic Chemistry in the University of Liverpool.
8. Mrs. Baly.
9. Prof. Ernest Barker, Litt.D., D.Litt., LL.D., Professor of Political Science in the University of Cambridge.
10. Mrs. E. Bishop.
11. Prof. V. H. Blackman, Sc.D., F.R.S., Professor of Plant Physiology and Director of the Biological Laboratories, Imperial College of Science and Technology, London.
12. Miss Blackman.
13. Prof. P. G. H. Boswell, O.B.E., D.Sc., F.R.S., Professor of Geology, Imperial College of Science and Technology.
14. Prof. P. A. Buxton, Professor of Medical Entomology, University of London; Director of the Department of Entomology, London School of Hygiene and Tropical Medicine.
15. Mrs. Buxton.
16. Mr. J. M. Caie, B.Sc., Assistant Secretary in the Department of Agriculture for Scotland.
17. Prof. G. D. Hale Carpenter, M.B.E., D.M., M.R.C.S., L.R.C.P., Hope Professor of Zoology (Entomology) in the University of Oxford.
18. Mrs. Hale Carpenter.
19. Prof. N. M. Comber, D.Sc., Professor of Agricultural Chemistry in the University of Leeds.
20. Miss Coxhead, Chemical Laboratories, Liverpool.
21. Prof. F. A. E. Crew, M.D., D.Sc., Ph.D., Professor and Director of the Institute of Animal Genetics in the University of Edinburgh.
22. Dr. E. M. Crowther, D.Sc., Head of the Chemistry Department, Rothamsted Experimental Station.
23. Prof. Winifred Cullis, C.B.E., D.Sc., LL.D., Sophia Jex-Blake Professor of Physiology, University of London, London (Royal Free Hospital) School of Medicine for Women.
24. Dr. C. D. Darlington, Ph.D., D.Sc., Cytologist in the John Innes Horticultural Institution.
25. Prof. C. G. Darwin, Sc.D., F.R.S., Master of Christ's College, Cambridge.
26. Mrs. Darwin.
27. Mr. T. S. Dymond.
28. Prof. Sir A. S. Eddington, D.Sc., LL.D., F.R.S., Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge.
29. Prof. C. B. Fawcett, D.Sc., Professor of Economic and Regional Geography in the University of London.
30. Prof. W. G. Fearnsides, F.R.S., Sorby Professor of Geology in the University of Sheffield.
31. Sir Lewis L. Fermor, O.B.E., D.Sc., F.R.S., formerly Director of the Geological Survey of India.
32. Lady Fermor.
33. Prof. R. A. Fisher, Sc.D., D.Sc., F.R.S., Galton Professor of Eugenics in University College, Galton Laboratory, University College, Gower Street, London.
34. Prof. H. J. Fleure, D.Sc., F.R.S., Professor of Geography in the University of Manchester.
35. Prof. F. E. Fritsch, D.Sc., Ph.D., F.R.S., Professor of Botany in the University of London.
36. Mrs. Fritsch.

37. Prof. R. Ruggles Gates, Ph.D., D.Sc., LL.D., F.R.S., Professor of Botany in the University of London (King's College).

38. Prof. W. T. Gordon, D.Sc., University Professor of Geology in the University of London (King's College).

39. Mr. H. M. Hallsworth, C.B.E., Member of the Unemployment Assistance Board (formerly Professor of Economics, Armstrong College, Newcastle-on-Tyne).

40. Prof. J. W. Heslop Harrison, Professor of Botany and Reader in Genetics, King's College, Newcastle-on-Tyne.

41. Sir James B. Henderson, LL.D., D.Sc., formerly Professor of Applied Mechanics in the Royal Naval College.

42. Lady Henderson.

43. Prof. J. Hendrick, B.Sc., Strathcona-Fordyce Professor of Agriculture in the University of Aberdeen.

44. Sir Arthur Hill, K.C.M.G., Sc.D., D.Sc., F.R.S., the Royal Botanic Gardens, Kew, Surrey.

45. Sir Frederick Hobday, C.M.G., formerly Principal and Dean of the Royal Veterinary College, London.

46. Dr. A. Hopwood, Analytical Chemist.

47. Mrs. Hopwood.

48. Dr. O. J. R. Howarth, O.B.E., Ph.D., Secretary of the British Association.

49. Mrs. Howarth.

50. Prof. G. W. O. Howe, D.Sc., James Watt Professor of Electrical Engineering in the University of Glasgow.

51. Sir James H. Jeans, D.Sc., Sc.D., LL.D., F.I.C., F.R.S., Past President, British Association.

52. Dr. Ll. Wynn Jones, Ph.D., Lecturer in Experimental Education in the University of Leeds.

53. Major J. Keith.

54. Mrs. Keith.

55. Miss E. E. Kelly, Chemical Laboratories, Liverpool.

56. Mr. R. H. Kinvig, Reader in Geography in the University of Birmingham.

57. Prof. J. E. Lennard-Jones, Ph.D., D.Sc., F.R.S., Plummer Professor of Theoretical Chemistry in the University of Cambridge.

58. Dr. Edward Mapother, Medical Superintendent and Lecturer in Psychological Medicine, Maudsley Hospital.

59. Mrs. Mapother.

60. Mr. J. McFarlane, Reader in Geography in the University of Aberdeen, Marischal College, Aberdeen.

61. Dr. C. S. Myers, C.B.E., M.D., Sc.D., D.Sc., F.R.S., Principal of the National Institute of Industrial Psychology, Aldwych House.

62. Dr. W. G. Ogg, Ph.D., Lecturer in Soil Science in the University of Aberdeen.

63. Prof. A. G. Ogilvie, O.B.E., Professor of Geography in the University of Edinburgh.

64. Mr. E. J. E. Peake, F.S.A., Ex-President of the Royal Anthropological Institute.

65. Dr. E. P. Poulton, M.D., F.R.C.P., Physician to Guy's Hospital, London.

66. Miss J. Poulton.

67. Prof. H. H. Read, D.Sc., George Herdman Professor of Geology in the University of Liverpool.

68. Prof. H. R. Robinson, Ph.D., D.Sc., F.R.S., Professor of Physics in the University of London (Queen Mary College).

69. Dr. R. N. Salaman, M.D., F.R.S., Director, Potato Virus Research Station, School of Agriculture, Cambridge.

70. Mrs. Salaman.

71. The Rt. Hon. Viscount Samuel, P.C., G.C.B., President, British Institute of Philosophy.

72. Lady Samuel.
73. Lt.-Col. R. B. Seymour Sewell, C.I.E., Sc.D., F.R.S., formerly Director of the Zoological Survey of India.
74 Prof. J. L. Simonsen, D.Sc., F.R.S., Professor of Chemistry, University College of North Wales.
75. Mrs. Simonsen.
76. Prof. R. V. Southwell, F.R.S., Professor of Engineering Science in the University of Oxford.
77. Prof. C. Spearman, Ph.D., LL.D., F.R.S., Emeritus Professor of Psychology in the University of London.
78. Dr. L. Dudley Stamp, D.Sc., Sir Ernest Cassel Reader in Economic Geography in the University of London.
79. Mrs. Stamp.
80. Dr. G. Arbour Stephens, M.D., Consulting Cardiologist, King Edward VII Welsh National Memorial Association.
81. Mrs. Arbour Stephens (Prof. Mary Williams, D.Litt., Professor of French Language and Literature in University College, Swansea).
82. Prof. F. J. M. Straton, D.S.O., O.B.E., Professor of Astrophysics in the University of Cambridge.
83. Prof. W. M. Tattersall, Professor of Zoology in the University College of South Wales.
84. Mrs. Tattersall.
85. Prof. F. W. Thomas, Anthropology Section, University of Oxford.
86. Sir Henry Tizard, C.B., F.R.S., Rector of the Imperial College of Science and Technology.
87. Dr. A. E. H. Tutton, D.Sc., F.R.S , formerly H.M Inspector of Schools.
88. Mr. J. A. Venn, Litt.D., President of Queen's College and Lecturer in the History and Economics of Agriculture in the University of Cambridge.
89. Prof. R. G. White, Professor of Agriculture in the University College of North Wales.

## Tour of the Delegates.

In addition to the delegates from the British Association, quite a number of other delegates who were specially invited from abroad to attend the Session joined the tour which were arranged through different cities of India on their way to Calcutta. These arrangements were made by the General Secretaries in consultation with and with the fullest co-operation of Prof. P. G. H. Boswell, a former General Secretary of the British Association, and Dr. O. J. R. Howarth, its Secretary.

The tour was arranged with a view to give the delegates an idea of the historical and cultural background of India, past and present, and to bring scientists in India and those coming from outside in mutual contact in as many centres of scientific activity as could be arranged for within the available time. Almost all the delegates including the ladies cheerfully bore the strain of the journey as also unavoidable inconveniences. It was possible to secure special corridor stock for the railway journey and this made it possible for the delegates to travel in relative comfort. The provision of a special train avoided the inconveniences accompanying frequent resort to hotels. The delegation attended numerous scientific and social engagements arranged by the Local Reception Committees. The delegates gave popular lectures as also addresses to various scientific institutions and attended convocations of several Universities. They also gave broadcast speeches at several places on topics of popular interest and consulted the various bodies on scientific matters of interest to them. Their visit evoked great interest and enthusiasm both amongst scientific men and the local public, at Calcutta in particular where the meeting of the Congress was held. One of the General Secretaries, Prof. J. N.

Mukherjee, who was responsible for the organization of the Local Reception Committees, accompanied the delegates in the tour preceding the Congress and to assist him an experienced tour manager recommended by Messrs. Thos. Cook & Son was appointed by the Indian Science Congress Association. A guide book giving general and historical informations regarding the places visited was specially prepared by one of the General Secretaries, Mr. W. D. West.

A brief description of the tour and of the scientific and social engagements arranged for the delegates is given below:

The main body of the delegates consisting of ninety members reached Bombay on December 17th, 1937. On landing, the party was received by Rao Bahadur T. S. Venkatraman, C.I.E., President of the Congress, Mr. N. Chandavarkar, Vice-Chancellor of the University and Chairman of the Local Reception Committee, Prof. J. N. Mukherjee, one of the General Secretaries, and other representatives. At Bombay, apart from contacts with scientific workers in the city, the party visited Departments of the University, the Royal Institute of Science, the Haffkine Institute, the Grant Medical College and other Institutions. Lectures or short addresses were given by Sir James Jeans and other members. The Local Reception Committee gave a dinner and a luncheon party and made arrangements for the transport of the delegates. They also distributed to the delegates a guide book giving useful information. The Congress arranged for the accommodation of the majority of the delegates at the Taj Mahal Hotel.

The party left Bombay on December 18th, and reached Hyderabad on December 19th. Here, they visited the site of the Osmania University, Golconda, a hill-fort and the tombs of the Kutb Shahi Kings of the 16th and 17th centuries and other places of interest. At Hyderabad, the visitors were the guests of the State which consequently made all the arrangements and met all expenses for transport during their stay in the State. The Rt. Hon'ble Sir Akbar Hydari, P.C., LL.D., and the Hon'ble Nawab Mehdi Yar Jung Bahadur, Vice-Chancellor of the Osmania University and Political Member of the State took personal interest in the visit and the arrangements made in this connection. There was a reception at the station at which Sir Akbar was present. Tea was arranged at Golconda and dinner at the University.

The party left Hyderabad for Aurangabad in a narrow gauge train. They were accompanied by two senior officers of the State Railway one of whom went up to Jalgaon and by Prof. M. Quereshi of the Osmania University who arduously supervised all the arrangements at Hyderabad and all through the way up to Jalgaon. The party spent a day and a night at Aurangabad. Comfortable arrangements for breakfast, dinner and tea were made by the State at the Railway siding. They visited the rock-hewn temples at Ellora, the hill-fortress of Daulatabad and other historic sites. Ajanta was visited on December 21st. From Aurangabad the party proceeded by road to Ajanta and thence to Jalgaon to rejoin the special train. Mr. Yazdani, the Curator of the State Museum, and his staff rendered all possible help at Ellora and Ajanta. The route from Aurangabad to Jalgaon covered a difficult tract of the country. The transport arrangements, however, stood the strain remarkably well. Luncheon was served at the rest house near Ajanta and tea at the caves.

The Buddhist Stupas and other remains at Sanchi in Bhopal State were visited on December 22nd. While visiting the Stupas they met a party of pilgrims who had come all the way from Japan doing homage to the Stupas accompanied by a Buddhist priest in yellow robes. Leaving Sanchi, Agra was reached in the evening of December 22nd. Some of the party visited the Taj Mahal the same night and it was here that in the darkness Dr. W. W. Vaughan met with the regrettable accident referred to above. The delegates were very keen on visiting the Taj by moon light and as the moon would not rise before about 10 P.M. the General Secretary suggested that he would meet them at 10-30 P.M. and accompany them to the Taj. But so great was their enthusiasm that most of them

had left before the arranged time. On December 23rd the members visited the Fort and the Taj Mahal and some of them were able to see the Fort of Fatehpur Sikri and also the Latitude Variation Observatory of the Survey of India, and the Upper Air Observatory of the Meteorological Department. Mr. Zafar Hussain of the Archæological Survey of India and his staff explained to the party the historical interest of the sites visited. Members of the University of Agra including Prof. K. C. Mehta, Mr. Mathur of the Survey of India, and Mr. G. C. Chatterjee and his colleagues of the Upper Air Observatory rendered great help to the party. Sir James Jeans addressed the students of the University and several others met groups of scientific workers at Agra.

The main party left Agra on December 23rd and reached Delhi on the following day. Some members diverged in order to visit Aligarh, where at the University short addresses were given by Sir Arthur Eddington, Prof. Ernest Barker and other members. At Delhi the party were received by Rao Bahadur T. S. Venkatraman, Sir Shah Sulaiman, Chairman of the Local Reception Committee, and Mr. J. E. Perkinson, Educational Commissioner to the Government of India and others. The party visited the Viceroy's house, the Imperial Secretariat and the Council House, the Imperial Institute of Agricultural Research as well as many historical monuments, such as, the Fort, the Palace, the Juma Masjid, the Kutb Minar and the famous iron pillar. On Christmas Eve the party were entertained to luncheon by the Government of India at which Sir Girja Sankar Bajpai, Secretary, Department of Education, Health and Land, presided. The Local Reception Committee arranged for a number of dinner parties on Christmas Eve given by prominent residents of Delhi and the delegates spent the evening with their respective hosts. Sir Shah Sulaiman gave an afternoon party and a party was given by Lala Sri Ram on the following day. The Local Reception Committee also distributed to the members a guide book containing information regarding places visited as a souvenir of their visit. Adequate transport arrangements supervised by the staff of the Educational Commissioner were made by the Government of India for the party.

From Delhi the party went to Dehra Dun where they visited the Forest Research Institute and the Geodetic Branch of the Survey of India. Mr. L. Mason, C.I.E., Inspector General of Forests, and Col. C. M. Thomson, Director of the Geodetic Branch of the Survey of India, received the party at the station. Mr. L. Mason made arrangements for the visit of the party to Mussoorie from where they had a view of the Himalayas. They left Dehra Dun on December 26th and reached Benares on the next day. They were received at the station by Raja Jwala Prasad, Pro-Vice-Chancellor of the Benares Hindu University and members of the staff. Visits were paid to the famous Asoka Pillar, the Stupas and other relics at Sarnath, the Hindu University and other places of interest. A boat trip along the Ganges was also arranged. Pandit Madan Mohan Malaviya, Vice-Chancellor of the Benares Hindu University, took personal interest in the arrangements which were supervised by Prof. S. S. Joshi and other members of the University. Members of the delegation were entertained to a luncheon in the University and attended its twentieth convocation at which honorary degrees were conferred on Sir James Jeans, Sir Arthur Eddington, Dr. F. W. Aston, Prof. E. C. C. Baly, Prof. V. H. Blackman, Prof. C. G. Jung and Prof. F. A. E. Crew.

Benares was left on December 28th and Calcutta reached on the day following. On the way to Calcutta the geologists in the party got down at Kodarma for a geological excursion arranged for them. Mr. W. D. West, General Secretary, Mr. B. M. Sen and Prof. S. K. Mitra, Local Secretaries, met them at the station. The majority of the members left Calcutta on the same day for a visit to Darjeeling. The party returned to Calcutta in the morning of January 2nd, and were received by Mr. S. P. Mookerjee, Vice-Chancellor of the Calcutta University and Chairman of the Reception Committee, by the Members of the Executive Committee of the Indian

Science Congress Association and the Local Secretaries, special officers and members of the Local Reception Committee. The events during the Meeting have been given in a previous section and it is not intended to repeat them but a short supplementary account is given below:

### The Delegates at Calcutta.

The housing arrangements including private hospitality for the delegates were made by the Local Secretaries, Prof. S. K. Mitra and Mr. B. M. Sen in consultation with the Local Reception Committee who also made all other local arrangements for the Meeting.

At Calcutta, the delegation had to attend to a crowded scientific and social programme. Their scientific activities were mainly concerned with the reading of papers and taking part in the discussions on the various topics arranged by the Congress. Public lectures were given by Sir James Jeans as also by Dr. F. W. Aston, Professor Ernest Barker (two), Prof. F. A. E. Crew, Dr. C. G. Darwin, Prof. Sir Arthur Eddington, Prof. H. J. Fleure and Dr. J. A. Venn. Among other lectures given by the members of the delegation to various scientific bodies in Calcutta were the following: At the Indian Association for the Cultivation of Science addresses were given by Sir James Jeans and Dr. F. W. Aston, both of whom received the Joykisson Mookerjee Medal. The Association also heard three lectures by Prof. J. E. Lennard-Jones and three by Sir Arthur Hill. Sir Henry Tizard and Prof. J. L. Simonsen addressed the Institute of Chemists; Sir Arthur Eddington, the Indian Physical Society and the Rotary Club; Prof. R. V. Southwell and Prof. G. W. O. Howe, the Institution of Engineers and Prof. Howe, the Association of Engineers. Dr. C. S. Myers gave four lectures in the University and Prof. C. G. Jung, two in the University College of Science. Broadcasts were given by Dr. W. G. Ogg, Sir Arthur Hill, Prof. P. G. H. Boswell, Dr. C. S. Myers, Sir Arthur Eddington and Prof. H. J. Fleure.

Following the garden party on January 7th a special convocation of the University of Calcutta was held at Government House at which honorary degrees were conferred on Sir James Jeans, Dr. F. W. Aston, Sir Arthur Eddington, Prof. Ernest Barker, Prof. A. H. R. Buller, Prof. R. A. Fisher, Prof. C. G. Jung, Dr. C. S. Myers and Prof. W. Straub. A civic reception was given by the Corporation of Calcutta on January 4th; a Science Congress dinner was held on January 8th; a farewell party was given by the University in the afternoon of January 9th. The hospitality of other official and non-official bodies and private residents was also extended to individual members and groups of members of the party.

At the time of leaving Calcutta Sir James Jeans issued the following message to the press:—

"At the moment of leaving Calcutta, the visiting scientific delegation tender their most sincere thanks to all the kind hosts who have helped to make their stay in Calcutta so enjoyable. The scientific Congress which we have been privileged to attend has impressed us all with its extraordinary vitality, with the wide-spread and generous attention accorded to our own contributions, and with the keen public interest which the transactions of the meeting have aroused; the huge audiences at the public lectures have been specially gratifying. I must reiterate our appreciation of the compliment paid by the Indian Science Congress Association to the British Association for the Advancement of Science in inviting its co-operation in the arrangement of the delegation; that invitation has forged a powerful new bond between Indian and British science, to the great advantage of both, and we all hope that the effects of that bond may prove wider even than the bounds of science. We offer our thanks to the Indian Science Congress Association, to its kindred scientific institutions, to the many organizations which have contributed to the success of the Congress, to the city and University of Calcutta and to the Province of Bengal.

The women of the party owe special gratitude to the ladies, resident in Calcutta, who have afforded them such ample opportunities for learning of the manifold interests of the city."

### The Post-Congress Tour.

On the conclusion of the Congress, quite a number of the delegates proceeded to different places to fulfil personal engagements of scientific interest and otherwise. A party of about fifty, however, left Calcutta for the Southern tour on January 9th. They reached Madras on January 11th, where they visited the Museum, the aquarium and other places of interest. They were entertained to a luncheon by the Vice-Chancellor, Mr. S. E. Ranganathan and Members of the University of Madras and attended a garden party arranged by the city in honour of the Viceroy.

On their way from Madras to Bombay the party went to Bangalore and Mysore City. At both the places the visitors were the guests of the State of Mysore. Sir Mirza Ismail, the Dewan of Mysore and Dr. N. S. Subba Rao, the Vice-Chancellor took a personal interest in the arrangements. Profs. A. Subba Rau and B. Venkatesachar were specially deputed to Calcutta to discuss the arrangements. Some members of the party at first expressed an apprehension about the strain of continued long journeys but they were so impressed with the arrangements and the sights at Mysore and Bangalore that later they expressed great satisfaction that they had not allowed their apprehension to interfere with the visit. At Mysore City, the Maharaja's Palace, the University, the Zoological Gardens and various Institutions were visited. The illuminated fountains at the great Dam on the river Cauvery and the city, brilliantly lit up, presented brilliant spectacles at night. After visiting the Fort at Seringapatam and the tombs of Hyder Ali and Tippu Sultan the party proceeded to Bangalore. Here again a number of Institutions including the Indian Institute of Science and the College of Science were visited. The party entrained at Bangalore on January 13th and proceeded direct to Bombay where on January 15th they embarked on the S.S. *Strathaird* for the return voyage.

Before leaving Bombay, Sir James Jeans, on behalf of the Delegation issued the following message through the press:—

"In taking leave of India, we of the Scientific Delegation desire again to express our thanks for the overwhelming kindness with which we have been received in all parts. A month ago we landed here, eagerly expectant of what we were to see and learn. We are now returning home after a journey of more than five thousand miles through the country, during which we have been able to visit many Monuments of ancient civilizations, and have admired the care with which the legacies of the past are preserved. But more of our time has been mooted to the present, and we have realized to the full the scientific and cultural developments which are in progress both in the Universities and in the field of practical applications throughout the country.

Nothing has more deeply impressed us than the interest shown in science by the country at large and the eagerness with which students are following and practising the most recent advances in research. India has achieved self-sufficiency in many directions, but there is an acknowledged need for influences which shall further bind together her varied races. Her achievements in the calms of thought and her progress in the development of industry lead us to the hope that science which transcends all national and racial frontiers, may provide such a unifying influence. Long may science continue to help in maintaining and advancing the position of India in the community of civilized nations."

After the return of the delegation to England, the Council of the British Association adopted the following resolution:—

'The Council of the British Association have learned with gratification of the complete success that attended the visit of the Scientific Delegation

to India, the members of which, through the invitation of the Indian Science Congress Association, were enabled to co-operate in its Jubilee Meeting in Calcutta, to visit many places of scientific and historical interest in India, to become acquainted with the work of many universities and other institutions, and to make or renew personal contacts with large numbers of Indian scientific workers and leaders of thought. The Council are glad to hear of the opinion, widely expressed in India, that much good would result from the visit, and this belief the Council heartily reciprocate. The Council desire to endorse the expressions of gratitude which have already been transmitted, on behalf of the delegation, to the Government of India, to all other participant authorities and individuals, and very specially to the executive of the Indian Science Congress Association.'

### B. (1) DELEGATES FROM ABROAD OTHER THAN THOSE REPRESENTING THE BRITISH ASSOCIATION.

Reference has been made in the report to the General Committee [*vide* Proceedings of the Twenty-fourth (Hyderabad) Meeting, page 607] to the proposal of inviting eminent scientists from abroad not connected with the British Association. Invitations were issued to all persons whose names had been suggested on various occasions. Most of them could not find it possible to accept the invitation to attend the meeting for diverse reasons. Prof. N. Bohr, Prof. L. Diels, Prof. N. I. Vavilov, Prof. L. Aschoff and others could not find it possible to attend even after they had accepted the invitation. The following delegates however found it possible to attend the meeting:

(1) Prof. L. F. de Beaufort, Director, Zoological Institute, Amsterdam.
(2) Mme. de Beaufort.
(3) Prof. W. Bothe, Director, Institute for Physics, Kaiser Wilhelm Institute for Medical Research, Heidelberg.
(4) Prof. A. H. R. Buller, Lately Professor of Botany in the University of Manitoba.
(5) Dr. A. L. du Toit, Consulting Geologist, Johannesburg, S. Africa.
(6) Mrs. du Toit.
(7) Prof. E. von Eickstedt, Director of the Anthropological Institute, Breslau.
(8) Prof. C. G. Jung, Professor of Psychology in the University of Zurich.
(9) Mr. Fowler McCormick, International Harvester Trust Co., Chicago.
(10) Prof. F. K. Morris, Ph.D., Professor of Structural Geology, Massachusetts Institute of Technology, Cambridge Mass., U.S.A.
(11) Mrs. Morris.
(12) Prof. W. Straub, Professor of Physiology in the University of Munich.
(13) Baron von Veltheim, Psychologist, Castle Ostean, near Halle Saale, Germany.

**B. (2) DELEGATES FROM UNIVERSITIES AND LEARNED SOCIETIES IN INDIA.**

*Agra University.*

1. Rai Bahadur Dr. K. C. Mehta.
2. Mr. P. P. Shahani.

*University of Allahabad.*

1. Dr. J. H. Mitter.
2. Prof. A. C. Banerji.

*Andhra University.*

1. Mr. S. Bhagavantham.
2. Dr. T. R. Seshadri.

*Annamalai University.*

1. Prof. A. Narasinga Rao.
2. Dr. S. Ramachandra Rao.

*Benares Hindu University.*

1. Dr. S. S. Joshi.
2. Prof. B. C. Chatterji.

*University of Bombay.*

1. Principal N. M. Shah.
2. Lt.-Col. S. L. Bhatia.
3. The Rev. G. Palacios.
4. Prof. R. B. Forster.
5. Dr. D. D. Karve.
6. Dr. K. Venkataraman.

*University of Dacca.*

1. Prof. J. C. Ghosh.
2. Prof. S. N. Bose.
3. Prof. N. M. Basu.
4. Mr H. D. Bhattacharyya.

*University of Delhi.*

1. Dr. B. D. Laroia.
2. Dr. D. S. Kothari.

*University of Lucknow.*

1. Dr. K. N. Bahl.
2. Prof. P. S. MacMahon.

*University of Madras.*

1. M.R.Ry. R. Gopala Ayyar Avl.
2. Dr. M. O. Parthasarathi Ayyangar.
3. Dr. M. Damodaran.
4. M.R.Ry. George Kuriyan Avl.

*Muslim University.*

1. Dr. R. K. Asundi.
2. Dr. M. Ishaq.
3. Dr. R. D. Desai.

*University of Mysore.*

1. Dr. A. Subba Rau.
2. Dr. B. Sanjiva Rao.

*Nagpur University.*

1. Mr. M. L. De.
2. Rao Saheb S. N. Godbole.

*Osmania University.*

1. Dr. H. Hyder Ali Khan.
2. Dr. M. Qureshi.

*Patna University.*

1. Dr. B. K. Singh.
2. Mr. P. K. Parija.

*University of the Punjab.*

1. Dr. S. S. Bhatnagar.
2. Dr. G. Matthai.

*University of Rangoon.*

Prof. F. Webster.

*Society of Biological Chemists, India.*

1. Dr. Gilbert J. Fowler.
2. Dr. V. Subrahmanyan.

*The Association of Engineers.*

1. Dr. Birendra Nath Dey.
2. Mr. Shachin Bandopadhyaya.

*The Institution of Engineers (India).*

1. Rai Bahadur V. P. Varma.
2. Mr. F. C. Griffin.

*Survey of India.*

Brigadier Lowis.

*Indian Medical Service.*

Major-General E. W. C. Bradfield.

*Royal Institute of Science.*

1. Dr. T. S. Wheeler.
2. Prof. G. R. Paranjpe.

*Associated Cement.*

1. Dr. Anitas and Mrs. Anitas.

## C. HONORARY SILVER JUBILEE SESSION MEMBERSHIP.

Proposals to confer some suitable form of recognition to eminent scientists attending the Silver Jubilee Session were received by the Executive Committee and with the approval of the Council they ultimately decided to create a special class of Honorary Silver Jubilee Session Members. Their privileges were defined as follows:

'The Honorary Silver Jubilee Members should be entitled to receive the Proceedings of the Indian Science Congress Association for life, even though they are not Ordinary Members.' (Executive Committee Meeting dated 10-12-37).

The names of the recipients of the Membership are given below, as well as in the Section on the Opening Proceedings. The Executive Committee in their original list naturally included the name of Sir J. C. Bose. His death on the 23rd November, 1937 was deeply mourned by the members of this Association who were eagerly looking forward to his participation in the Meeting. The token of the award was worded as given on the next page.

Sir James H. Jeans.
Sir P. C. Ray.
Sir Arthur Eddington.
Sir M. Visvesvarya (*in absentio*).
Prof. C. G. Jung.
Sir C. V. Raman (*in absentio*).
Dr. F. W. Aston.
Prof. M. N. Saha.
Prof. L. F. de Beaufort.
Sir Frederick Hobday.
Prof. J. L. Simonsen.
Prof. A. H. R. Buller.

# THE

# INDIAN SCIENCE CONGRESS

THE INDIAN SCIENCE CONGRESS ASSOCIATION

ON THE OCCASION

OF ITS

TWENTY-FIFTH SESSION

IN TOKEN OF

THE FELLOWSHIP OF HUMAN LEARNING

APPOINTS

.....................................

AN HONORARY SILVER JUBILEE MEMBER

IN APPRECIATION

OF HIS SCHOLARLY EMINENCE

| | | |
|---|---|---|
| (Sd.) W. D. West | (Sd.) T. S. Venkatraman | (Sd.) J. N. Mukherjee |
| *General Secretary* | *President* | *General Secretary* |

CALCUTTA, THE 2ND JANUARY, 1938.

## D. SPECIAL PUBLICATIONS.

Of the special publications intended to be issued in connection with the Silver Jubilee Session the book entitled "An Outline of the Field Sciences of India" edited by Dr. S. L. Hora was published in time for the meeting. It contains the following contributions:

The Weather of India. By C. W. B. Normand, M.A., D.Sc., F.N.I.
The Oceans round India. By R. B. Seymour Sewell, C.I.E., Sc.D., F.N.I., F.R.S., Lieut.-Col., I.M.S. (retired).
An Outline of the Geological History of India. By D. N. Wadia, M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I.
An Outline of the Vegetation of India. By C. C. Calder, B.Sc., B.Sc. (Agri.), F.L.S., F.R.H.S., F.N.I.
An Outline of the Fauna of India. By H. Srinivasa Rao, M.A., D.Sc., F.A.Sc.
An Outline of the Racial Ethnology of India. By B. S. Guha, M.A., Ph.D., F.N.I.
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The publication of the volume on "The Progress of Science in India during the past Twenty-five Years" edited by Dr. B. Prashad was unavoidably delayed but has been published since the meeting. It contains the following articles:

Introduction. By B. Prashad, D.Sc., F.R.S.E., F.L.S., F.Z.S., F.N.I., F.R.A.S.B.
Progress of Scientific Education in India during the past twenty-five years. By W. A. Jenkins, D.Sc., I.E.S.
Progress of Mathematical Research in India during the past twenty-five years. By B. M. Sen, M.A., M.Sc., F.N.I., I.E.S.
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Progress of Geology and Geography in India during the past twenty-five years. By D. N. Wadia, M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I.
Progress of Agricultural Science in India during the past twenty-five years. By W. Burns, D.Sc., I.A.S.
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Progress of Botany in India during the past twenty-five years. By S. P. Agharkar, M.A., Ph.D., F.L.S., F.N.I.

Of the other two volumes the Executive Committee had decided after the meeting only to proceed with the publication of "the History of the Indian Science Congress Association" of which Prof. S. P. Agharkar is the editor. The honorary services rendered by the contributors to these volumes and the editors are gratefully appreciated by the Indian Science Congress Association.

## E. FINANCIAL ARRANGEMENTS FOR THE SILVER JUBILEE SESSION.

The following contributions were received towards the expenses of the Silver Jubilee Session *vide* page 608, Proceedings of the Twenty-fourth (Hyderabad) Meeting.

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[2] In addition a sum of Rs.5,000 has been donated towards the Reserve Fund.

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The British Association collected a sum of £1,356-11-0 and made in addition a contribution from its own funds towards the cost of the travelling expenses of its delegation.

A sum of Rs.43,490-10-0 equivalent to £3,275 was paid to the British Association to cover the expenses of the President and the Delegates of the British Association. Inclusive of this amount the British Association paid a total sum of £4,590 as grants in aid for the purpose. Other incidental expenses [1], which have been met by the Indian Science Congress Association in connection with the supervision of the tour, in addition to the Railway fares [2] and catering charges, etc. which were paid for by the delegates, amount to Rs.5,393-10-6. A sum of Rs.11,043-12-3 was paid to the delegates other than those included in the British Association Delegation.

THE LOCAL RECEPTION COMMITTEE.

The Local Reception Committee made all local arrangements necessary for the transaction of the scientific work of the meeting and all local arrangements regarding social functions and accommodation of the members of the Congress and the delegates.

In addition to the usual arrangements, e.g. supplying informations regarding accommodation, arrival and departure of trains, registration of accommodation in hotels, etc., the Local Reception Committee specially arranged for the accommodation of about 150 members in the Hardinge Hostel of the Law College and in the Ashutosh Buildings. About 50 delegates from abroad were accommodated as guests of members of the Local Reception Committee and their friends, and the rest of the delegations were put up at the Grand Hotel.

The total sum raised by the Local Reception Committee amounted to Rs.25,714-3-9 (*vide* a statement of account published on page 79). Of this Rs.20,086 were received as donation. The total expenditure amounted to Rs.25,376-2-9. The Local Reception Committee has contributed from its surplus a sum of Rs.338-1-0 to the Indian Science Congress Association to meet the expenses of the Silver Jubilee Session.

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[2] The E.I. and the G.I.P. Railways very kindly agreed to charge a concession rate of three-fourths of a first class fare for the journey over their Railways.

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| Mr. T. J. Hornblower (Saxby & Farmer (Ind.) Ltd.) .. | 50 | 0 | 0 |
| Mr. B. K. Kashyap .. .. .. .. | 50 | 0 | 0 |
| Stewarts & Lloyds of India Ltd. & Indian Tube Co., Ltd. | 50 | 0 | 0 |
| Dr. B. P. Tribedi .. .. .. .. | 50 | 0 | 0 |
| Dr. S. C. Chatterjee, C.M.O. (E.B.Ry.) .. .. | 50 | 0 | 0 |
| Mr. T. A. Curry .. .. .. .. | 50 | 0 | 0 |
| Dr. K. S. Ray .. .. .. .. | 50 | 0 | 0 |
| Prof. P. N. Ghosh .. .. .. .. | 50 | 0 | 0 |
| Lt.-Col. J. C. De .. .. .. .. | 50 | 0 | 0 |
| Dr. A. C. Ukil .. .. .. .. | 50 | 0 | 0 |
| Lt.-Col. H. E. Murray .. .. .. .. | 50 | 0 | 0 |
| Sir H. Suhrawardy .. .. .. .. | 50 | 0 | 0 |

| | Rs. | A. | P. |
|---|---|---|---|
| Dr. Charu Chandra Basu | 50 | 0 | 0 |
| Dr. Asoke Nath Bose | 50 | 0 | 0 |
| Dr. H. Ghosh | 50 | 0 | 0 |
| Mr. J. De, I.C.S. | 50 | 0 | 0 |
| Mr. G. Peace | 50 | 0 | 0 |
| Principal R. Wolfenden | 50 | 0 | 0 |
| Dr. S. K. Pramanik | 50 | 0 | 0 |
| Mr. P. J. Kerr | 50 | 0 | 0 |
| Mr. H. H. Burn (MacLeod & Co., Ltd.) | 50 | 0 | 0 |
| Mr. S. C. Mukerjee, I.C.S. (Retd.) | 50 | 0 | 0 |
| Mr. H. P. Townend, I.C.S. | 50 | 0 | 0 |
| Mr. A. K. Ganguli (Scientific Instrument Co., Ltd.) | 50 | 0 | 0 |
| Dr. H. Thomas | 50 | 0 | 0 |
| The Hon'ble Mr. Nauser Ali | 50 | 0 | 0 |
| Major D. Ahmed | 50 | 0 | 0 |
| Mr. S. K. Sen | 50 | 0 | 0 |
| Kumar Bahadur, Lalgola | 50 | 0 | 0 |
| Dr. P. Neogi | 50 | 0 | 0 |
| Mr. J. M. Sen | 50 | 0 | 0 |
| Hon'ble Mr. N. R. Sarkar | 50 | 0 | 0 |
| Prof. S. C. Mahalanobis | 50 | 0 | 0 |
| Dr. Baini Prashad | 50 | 0 | 0 |
| Mr. C. H. Holmes (Britannia Bldg. & Iron Co., Ltd.) | 50 | 0 | 0 |
| Rev. Father A. Verstraeten, S.J. | 50 | 0 | 0 |
| Rai Radha Krishna Jalan Bahadur | 50 | 0 | 0 |
| Mr. S. K. Chakraborty | 50 | 0 | 0 |
| Hon'ble Mr. Justice N. G. A. Edgley | 50 | 0 | 0 |
| Mr. A. N. Chaudhuri | 50 | 0 | 0 |
| Mr. J. M. Bottomley | 50 | 0 | 0 |
| Sir Badridas Goenka | 50 | 0 | 0 |
| Dr. Amulyaratan Chakravarti | 50 | 0 | 0 |
| Mr. Hirendra Nath Datta | 50 | 0 | 0 |
| Mr. H. P. Bhaumik | 50 | 0 | 0 |
| Dr. Bamandas Mukherjee | 50 | 0 | 0 |
| Mr. D. P. Khaitan | 50 | 0 | 0 |
| Dr. B. N. Ghosh | 50 | 0 | 0 |
| Major General P. S. Mills | 50 | 0 | 0 |
| Dr. Bidhan Ch. Ray | 50 | 0 | 0 |
| Mr. Nibaran Ch. Ray | 50 | 0 | 0 |
| Mr. J. N. Mukherji | 50 | 0 | 0 |
| Dr. K. Biswas | 50 | 0 | 0 |
| Prof. D. M. Bose | 50 | 0 | 0 |
| Mr. Banowari Lal Roy | 50 | 0 | 0 |
| Mr. N. N. Chhotai (Das & Co.) | 50 | 0 | 0 |
| Girija Prasanna Chakravarti (Mohini Mills) | 50 | 0 | 0 |
| Mr. R. Chakravarti | 50 | 0 | 0 |
| Mr. S. P. Mookerjee | 50 | 0 | 0 |
| Rai Bahadur Dr. K. N. Bagchi | 50 | 0 | 0 |
| Mr. W. M. Roy | 50 | 0 | 0 |
| Mrs. W. M. Roy | 50 | 0 | 0 |
| Khan Bahadur K. M. Asadullah | 50 | 0 | 0 |
| Dr. W. A. Jenkins | 50 | 0 | 0 |
| Prof. P. C. Mahalanobis | 50 | 0 | 0 |
| Dr. Sunil Chandra Bose | 50 | 0 | 0 |
| Prof. B. C. Guha | 50 | 0 | 0 |
| Dr. P. N. Ray | 50 | 0 | 0 |
| Prof. S. P. Agharkar | 50 | 0 | 0 |
| Major P. Bardhan | 50 | 0 | 0 |
| Dr. P. C. Mitter | 50 | 0 | 0 |
| Prof. S. Dutta | 50 | 0 | 0 |

| | Rs. | A. | P. |
|---|---|---|---|
| Lt.-Col. E. H. Vere-Hodge, I.M.S. | 50 | 0 | 0 |
| Lt.-Col. E. O'G. Kirwan, I.M.S. | 50 | 0 | 0 |
| Major S. D. S. Greval | 50 | 0 | 0 |
| Bt.-Col. R. N. Chopra | 50 | 0 | 0 |
| Hon'ble Maharaja Sris Chandra Nandy of Kashimbazar | 50 | 0 | 0 |
| Prof. B B. Ray | 50 | 0 | 0 |
| Dr. Nabajiban Banerji | 50 | 0 | 0 |
| Mr. J. M. Majumdar | 50 | 0 | 0 |
| Mr. J. C. Mukherjee | 50 | 0 | 0 |
| Mr. Asoke Chatterji | 50 | 0 | 0 |
| Mr. Sanat Kumar Roy Chowdhury | 50 | 0 | 0 |
| Mr. G. L. Mehta | 50 | 0 | 0 |
| Sir Nilratan Sircar, Kt. | 50 | 0 | 0 |
| Mr. Atul Chandra Gupta | 50 | 0 | 0 |
| Mr. W. C. Wordsworth | 50 | 0 | 0 |
| Lt.-Col. T. M. M. Penney | 50 | 0 | 0 |
| Mr. Phulshanker A. Dave | 50 | 0 | 0 |
| Dr. Panchanan Chatterjee | 50 | 0 | 0 |
| Mr. S. N. Mitter | 50 | 0 | 0 |
| Mr. P. Ray Chowdhuri (Mitters Ltd.) | 50 | 0 | 0 |
| Mr. S. C. Roy | 50 | 0 | 0 |
| Mr. M. H. B. Lethbridge | 50 | 0 | 0 |
| Dr. A. M. Heron | 50 | 0 | 0 |
| Prof. J. N. Mukherjee | 50 | 0 | 0 |
| Mr. N. C. Chatterjee | 50 | 0 | 0 |
| Dr. S. K. Mukherjee | 50 | 0 | 0 |
| The Hon'ble Nawab Musharraf Hossain | 50 | 0 | 0 |
| The Hon'ble Mr. H. S. Suhrawardy | 50 | 0 | 0 |
| Principal B. M. Sen | 50 | 0 | 0 |
| Prof. S. K. Mitra | 50 | 0 | 0 |
| Miscellaneous | 50 | 0 | 0 |
| TOTAL | 20,086 | 0 | 0 |

LIST OF CONTRIBUTORS TO THE INDIAN DELEGATION FUND OF THE BRITISH ASSOCIATION.

| | £ | s. |
|---|---|---|
| W. H. Allen & Sons | 10 | 0 |
| Anglo-Iranian Oil Co. | 100 | 0 |
| Babcock, Wilcox & Co. | 10 | 0 |
| Baroda, Maharaja Gaekwar of | 100 | 0 |
| G. Bell & Sons | 10 | 10 |
| Bengal Dooars Rly. | 5 | 5 |
| Bengal & North Western Rly. | 20 | 0 |
| Blackie & Sons | 25 | 0 |
| Bombay, Baroda & Central India Rly. | 21 | 0 |
| British India S.N. Co. | 50 | 0 |
| Buck & Hickman | 1 | 1 |
| Callender's Cable Co. | 10 | 0 |
| Cambridge University Press | 15 | 0 |
| Dunlop Rubber Co. | 25 | 0 |
| East India Distilleries | 10 | 10 |
| General Electric Co. | 100 | 0 |
| Henley's Telegraph Co. | 10 | 10 |
| Imperial Airways | 50 | 0 |
| I.C.I. | 100 | 0 |
| Institution of Electrical Engineers | 50 | 0 |
| Longmans, Green & Co. | 5 | 5 |

| | £ | s. |
|---|---|---|
| Macmillan & Co. .. . . .. | 25 | 0 |
| Mather & Platt .. .. .. .. | 10 | 10 |
| Mirrlees, Bickerton, Ltd. . . . | 5 | 5 |
| Mirrlees, Watson, Ltd. .. .. .. . | 5 | 5 |
| Mocatta & Goldsmid . . .. | 10 | 0 |
| Mohan Singh, Sardar Bahadur Sardar . .. | 20 | 0 |
| Mond Nickel Co. . . . | 20 | 0 |
| R. Nivison & Co. .. .. .. . | 105 | 0 |
| Ralli Bros. .. .. . | 100 | 0 |
| Rendel, Palmer & Tritton . .. | 25 | 0 |
| Rohilkund & Kumaon Rly. . .. . | 5 | 0 |
| W. M. Simons & Co. . . .. . | 5 | 5 |
| Sir Findlater Stewart .. . .. .. | 5 | 0 |
| Thompson Boilers, Ltd. .. .. .. | 2 | 2 |
| Wakefield & Co. .. .. . | 52 | 10 |
| Worthington & Simpson .. .. .. .. | 3 | 3 |
| Yule, Catto & Co. .. .. .. .. | 100 | 0 |
| TOTAL .. | £1,228 | 1 |

The P. & O. Steam Navigation Co. granted one free first and one free second class passage, the equivalent of a contribution of £199 to the fund.

Sir Findlater Stewart, of the India Office, and Mr. R. W. Allen, gave generous personal help in collecting the fund.

## F. MEETINGS OF THE GENERAL COMMITTEE, THE COUNCIL, AND THE EXECUTIVE COMMITTEE OF THE INDIAN SCIENCE CONGRESS ASSOCIATION.

### 1. Meeting of the General Committee.

A meeting of the General Committee was held at 2 P.M. on Saturday, January 8th, 1938 in the Senate Hall, Calcutta, with Sir James H. Jeans, the President, in the chair. The following items of business were transacted:

(1) The minutes of the last meeting held on January 5th, 1937, in the Address Hall, Osmania University, Hyderabad, Deccan, were confirmed.

(2) The General Secretary reported to the meeting the names of the Honorary Silver Jubilee Members.

(3) Proposals made by Prof. B. K. Das, Prof. H. P. Chaudhuri, Dr. S. L. Hora and the Executive Committee for alterations to the rules of the Association were postponed for consideration by the next meeting with the consent of the members mentioned above who had acceded to the request of the Executive Committee to do so.

(4) The President announced the following names of five Ordinary Members elected to the Executive Committee under rule 13, and of five Ordinary Members elected to the Council under rule 17 for the year 1938-39:

| *Executive Committee.* | *Council.* |
|---|---|
| (1) Rao Bahadur T. S. Venkatraman. | (1) Prof. S. S. Bhatnager. |
| (2) Prof. K. S. Krishnan. | (2) Prof. S. N. Bose. |
| (3) Rai Bahadur Dr. S. L. Hora. | (3) Mr. D. N. Wadia. |
| (4) Prof. P. C. Mitter. | (4) Prof. K. N. Bahl. |
| (5) Prof. S. P. Agharkar. | (5) Dr. S. K. Banerjee. |

(5) The President announced that the twenty-sixth Session of the Congress will be held in Lahore under the auspices of the Punjab University.

(6) The President announced the names of the President, Sectional Presidents and Recorders of the 26th Session as follows:

*President.*

Professor J. C. Ghosh, D.Sc., F.N.I.

| | *Section.* | *President.* | *Recorder.* |
|---|---|---|---|
| 1. | *Mathematics and Physics.* | Dr. K. R. Ramanathan. | Dr. D. S. Kothari. |
| 2. | *Chemistry* .. | Dr. P. B. Sarkar .. | Dr. S. S. Joshi. |
| 3. | *Geology* .. | Prof. S. K. Roy .. | Dr. C. Mahadevan. |
| 4. | [1] *Geography and Geodesy.* | Mr. N. Subrahmanyam. | Dr. S. P. Chatterjee. |

[1] The Executive Committee decided at its Meeting held on the 31st January, 1938, to retain the Section as an independent Section. The names of Sectional Officers for the Section of Geography and Geodesy had already been nominated by the Sectional Committees subject to the approval by the Executive Committee in anticipation of the Section being made permanent.

| | *Section.* | *President.* | *Recorder.* |
|---|---|---|---|
| 5. | *Botany* .. | Dr. K. D. Bagchee .. | Prof. Y. Bharadwaja. |
| 6. | *Zoology* .. | Prof. C. R. Narayan Rao | Dr. S. G. Manavala Ramanujam. |
| 7. | *Anthropology* | Dr. D. N. Majumdar .. | Capt. R. N. Basu. |
| 8. | *Medical and Veterinary Research.* | Prof. T. S. Tirumurti .. | Dr. Phanindranath Brahmachari. |
| 9. | *Agriculture* | Rao Sahib Dr. T. V. Ramakrishna Ayyar. | Dr. C. N. Acharya. |
| 10. | *Physiology* | Prof. N. M. Basu .. | Prof. B. Narayana. |
| 11. | *Psychology* | Mr. H. P. Maiti .. | Dr. D. D. Shendarkar. |

(7) Mr. W. D. West was reappointed as a General Secretary for a period of five years from February 1st, 1938.

(8) The following were elected members of the Sectional Committees for the year 1938-39:

| | | |
|---|---|---|
| 1. | *Mathematics and Physics* .. | 1. Prof. J. Ghosh. |
| | | 2. Prof. A. C. Banerji. |
| 2. | *Chemistry* .. .. | 1. Prof. B. C. Guha. |
| | | 2. Dr. S. P. Ray-Chaudhuri. |
| 3. | *Geology* .. . | 1. Dr. M. R. Sahni. |
| | | 2. Dr. T. Das-Gupta. |
| 4. | *Botany* .. . | 1. Dr. S. N. Das-Gupta. |
| | | 2. Mr. A. C. Joshi. |
| 5. | *Zoology* .. . | 1. Dr. B. K. Das. |
| | | 2. Mr. G. K. Chakravarti. |
| 6. | *Anthropology* .. . | 1. Dr. P. C. Biswas. |
| | | 2. Prof. M. H. Krishna. |
| 7. | *Agriculture* .. .. | 1. Prof. J. C. Luthra. |
| | | 2. Mr. N. L. Dutt. |
| 8. | *Medical and Veterinary Research* | 1. Capt. S. Datta. |
| | | 2. Rai Bahadur K. N. Bagchi. |
| 9. | *Physiology* .. .. | 1. Dr. B. B. Sarkar. |
| | | 2. Dr. S. N. Ray. |
| 10. | *Psychology* .. .. | 1. Principal H. Hyder Ali Khan. |
| | | 2. Mr. G. Pal. |

(9) The audited accounts upto November 30th, 1937, were adopted.

(10) The following votes of thanks were unanimously adopted:

(i) A vote of thanks proposed by the President to H.E. the Viceroy, for accepting the Patronship of the Association, and for opening the Session.

(ii) A vote of thanks proposed by the President to H.E. the Governor of Bengal, for accepting the Patronship of the Association, and for gracing the occasion on the opening of the Session with his presence.

(iii) A vote of thanks proposed by the President to the University of Calcutta and its Vice-Chancellor, Mr. S. P. Mookerjee.

(iv) A vote of thanks proposed by Prof. S. P. Agharkar to the Government of India and to the Hon'ble Kunwar Sir Jagdis Prasad, Member of the Viceroy's Council in charge of the Department of Health, Education and Lands.

(v) A vote of thanks proposed by Rao Bahadur T. S. Venkatraman to the Government of Bengal.

(vi) A vote of thanks proposed by Prof. J. N. Mukherjee to the University of Bombay and its Vice-Chancellor, Mr. M. N. Chandavarkar.

(vii) A vote of thanks proposed by Prof. J. N. Mukherjee to H.E.H. the Nizam's Government, the Rt. Hon. Sir Akbar

Hydari, the Osmania University and its Vice-Chancellor, Nawab Mehdi Yar Jung.

(viii) A vote of thanks proposed by Prof. J. N. Mukherjee to the Benares Hindu University and its Vice-Chancellor, Pandit Madan Mohan Malaviya.

(ix) A vote of thanks proposed by Prof. J. N. Mukherjee to the University of Madras and its Vice-Chancellor, Dewan Bahadur S. E. Ranganathan.

(x) A vote of thanks proposed by Prof. J. N. Mukherjee to the Hon'ble Sir Mirza M. Ismail, the Dewan of Mysore and to the University of Mysore and its Vice-Chancellor, Mr. S. N. Subba Rao.

(xi) A vote of thanks proposed by Prof. J. N. Mukherjee to the Hon'ble Sir Shah Sulaiman.

(xii) A vote of thanks proposed by Prof. J. N. Mukherjee to Sir Girja Sankar Bajpai.

(xiii) A vote of thanks proposed by Prof. P. G. H. Boswell to the Chairman and Members of the Local Reception Committee.

(xiv) A vote of thanks proposed by Prof. J. L. Simonsen to the Local Secretaries and Volunteers.

(xv) A vote of thanks proposed by Prof. B. Sahni to the General Secretaries.

(xvi) A vote of thanks proposed by Rao Bahadur T. S. Venkatraman to the President.

(xvii) A vote of thanks proposed by Prof. J. C. Ghosh to the Royal Asiatic Society of Bengal.

(xviii) A vote of thanks proposed by Prof. M. N. Saha to the British Association for the Advancement of Science, for holding a Joint Session with the Indian Science Congress.

## 2. Meeting of the Council.

A meeting of the Council was held at 7-45 P.M. on January 3rd, 1938 in the Senate Hall of the University of Calcutta. The following were among the important items of business transacted at the meeting:

(1) It was agreed that the present practice of accepting more papers than can be adequately dealt with at the Session of the Congress " was not altogether satisfactory and it was decided to request the Executive Committee to appoint a sub-committee to consider the views of sections whose opinion had already been asked for on this point, and to report to the Council at its next meeting ".

(2) The General Secretary pointed out that with the present size of the Association, and with the increase in the amount of its publications, the work of running the Congress had lately increased so greatly that not only did it disturb the regular work of the Royal Asiatic Society, but it had become very difficult for the General Secretaries to control the work of administration without the help of a permanent whole time staff. The Managing Secretary pointed out that the present arrangement between the Royal Asiatic Society of Bengal and the Science Congress, while it had generally worked smoothly, had in it an element of divided control which was liable to lead to difficulties.

The desirability of the Association having its own permanent staff was agreed to in principle, and it was decided that the matter should be discussed with the Royal Asiatic Society of Bengal. It was also decided that as the question primarily depended upon the financial resources of the Association, it was desirable to obtain an annual grant from the Government of India, and the Executive Committee were authorized to approach the Government of India in this connection.

(3) A suggestion made at the meeting that the Section of Mathematics and Physics should be divided into two sections was referred to the Sectional Committee of the Mathematics and Physics Section for their opinion

and the Executive Committee were authorized to take necessary action after considering the report of the Sectional Committee.

## 3. Meetings of the Executive Committee.

Sixteen meetings of the Executive Committee including two emergency meetings were held during the year 1937-38. The following were among the important items of business transacted:

(1) To ensure prompt action it was resolved to authorize the General Secretaries to take such action as may be necessary on behalf of the Executive Committee regarding arrangements for the Jubilee Session.

(2) Prof. S. K. Mitra and Principal B. M. Sen, Local Secretaries of the Jubilee Session, were co-opted as members of the Executive Committee.

(3) Prof. M. N. Saha was appointed President of the Section of Mathematics and Physics in place of Sir C. V. Raman who declined the appointment.

(4) It was decided to use 'Scicong' as the telegraphic code word for the Association.

(5) A design for membership badges as contemplated in regulation D (1) was adopted and metal (for Ordinary and Full Session) and silk badges (for Associate and Student) were issued free to members.

(6) A grant of Rs.250 each for the year 1938 was sanctioned to the *Current Science* and to the *Indian Science News Association* (Science and Culture).

(7) It was decided to pay Rs.600 to the Royal Asiatic Society of Bengal as a token grant for the year 1938-39.

(8) The invitation of the Punjab University to hold the 1939 Session of the Congress at Lahore was accepted and the University of Madras were informed that the Executive Committee would be glad to avail of their invitation to hold a meeting under their auspices at the earliest opportunity.

(9) The appointment of Prof. J. C. Ghosh as President of the Association for the year 1939 was confirmed.

(10) Sectional Presidents, Recorders, Sectional Correspondents and Local Sectional Secretaries for the next Session were nominated after consideration of the recommendations of the Sectional Committee. The names of Sectional Presidents and Recorders have been given in Section dealing with the meeting of the General Committee and the names of Sectional Correspondents and Local Sectional Secretaries for the Session 1938-39 are given below:

*Section of Mathematics and Physics.*

| | |
|---|---|
| Sectional Correspondent .. | Dr. S. C. Sircar, Calcutta. |
| Local Sectional Secretary .. | Dr. P. K. Kichlu, Lahore. |

*Section of Chemistry.*

| | |
|---|---|
| Sectional Correspondent .. | Mr. S. N. Mukherjee, Calcutta. |
| Local Sectional Secretary .. | Dr. N. A. Yajnik, Lahore. |

*Section of Geology.*

| | |
|---|---|
| Sectional Correspondent . | Mr. N. N. Chatterjee, Calcutta. |
| Local Sectional Secretary .. | Dr. N. K. Bose, Lahore. |

*Section of Geography and Geodesy.*

| | |
|---|---|
| Sectional Correspondent .. | Mr. A. K. Banerjee, Calcutta. |
| Local Sectional Secretary .. | Mr. E. T. Dean, Lahore. |

*Section of Botany.*

| | |
|---|---|
| Sectional Correspondent . | Dr. J. C. Sen Gupta, Calcutta. |
| Local Sectional Secretary | Dr. P. L. Anand, Lahore. |

*Section of Zoology.*

| | | |
|---|---|---|
| Sectional Correspondent | .. | Mr. J. L. Bhaduri, Calcutta. |
| Local Sectional Secretary | .. | Dr. Vishwa Nath, Lahore. |

*Section of Anthropology.*

| | | |
|---|---|---|
| Sectional Correspondent | .. | Mr. S. S. Sarkar, Dhakuria. |
| Local Sectional Secretary | .. | Mr. C. R. Roy, Karachi. |

*Section of Medical and Veterinary Research.*

| | | |
|---|---|---|
| Sectional Correspondent | .. | Rai Bahadur K. N. Bagchi, Calcutta. |
| Local Sectional Secretary | .. | Dr. Vishwa Nath, Lahore. |

*Section of Agriculture.*

| | | |
|---|---|---|
| Sectional Correspondent | .. | Dr. R. P. Mitra, Calcutta. |
| Local Sectional Secretary | .. | Dr. A. N. Puri, Lahore. |

*Section of Physiology.*

| | | |
|---|---|---|
| Sectional Correspondent | .. | Dr. B. Mukherji, Calcutta. |
| Local Sectional Secretary | .. | Dr. Khem Singh Grewal, Lahore. |

*Section of Psychology.*

| | | |
|---|---|---|
| Sectional Correspondent | .. | Mr. S. K. Bose, Calcutta. |
| Local Sectional Secretary | .. | Mr. S. S. Jalota, Lahore. |

(11) Dr. G. S. Thaper, Recorder of the Zoology Section, having been unable to attend the session in Calcutta, Mr. D. D. Mukerji was appointed by the Zoology Sectional Committee to act in his place as Recorder for the Session.

(12) The recommendation of the Section of Geology that the Section of Geography and Geodesy be retained as an independent section was accepted.

## G. RESOLUTIONS ADOPTED BY SECTIONS.

*Section of Geography and Geodesy.*

1. The Section of Geography and Geodesy adopted a resolution that the section should continue to remain an independent section. It was supported by all the overseas delegates.

2. The British Geographers who attended the meetings of the section have drawn the attention of the Indian Science Congress Association to the need for the establishment of a central students' Library which may lend books and maps to local libraries. Such a library will, in their opinion, materially conduce to research work and study of geography in India. They further suggested that all Government publications that might be useful for research should be made available to all Universities in India.

3. A committee of five members with Mr. N. Subrahmanyam as convener was appointed to go into the question of co-ordinating the geographical work done in the several provinces and states and to present a report to the section at the 26th meeting of the Congress at Lahore in January, 1939.

*Section of Botany.*

The following resolutions were adopted in connection with the discussion on A National Herbarium:

(1) That there should be a National Herbarium for India for the use of Botanists, Foresters and Agriculturists and for the preparation of Local and Provincial Flora.

(2) That the existing Herbarium at Sibpur should form the basis or nucleus of the National Herbarium and that it should be located there.

(3) The existing provision for the assistant for India at Kew should be utilized for deputing members of the herbarium and university staff to Kew as Liaison Officers for 2-3 years.

(4) The staff at Sibpur Herbarium is not sufficient and that the post of systematic Assistant retrenched by the Government of India as a measure of economy in 1932 be restored.

A Committee was formed to consider all the details of the question, to devise ways and means and to take necessary steps in connection with the proposed National Herbarium. The Committee consist of the following members (cf. pp. 54 of the Minutes):

| | |
|---|---|
| *Convener* .. .. . | Dr. S. P. Agharkar. |
| *Members* .. .. . | Dr. B. Sahni.<br>Dr. M. Mitra.<br>Dr. K. Biswas.<br>Dr. K. Bagchee.<br>Dr. K. C. Behta.<br>Mr. S. N. Bal. |
| *To be consulted* .. .. | Sir Arthur Hill.<br>Col. Chopra. |

*Section of Zoology.*

That this meeting of the Zoology Section of the Indian Science Congress Association in session at Calcutta urges upon the Government of India the necessity and importance of constituting an all India Department of Fisheries for the development of the fishery resources of Indian waters on

scientific lines. It is of opinion that the commercial development of the fisheries of India should be accompanied by the scientific investigation of fishery problems by means of a carefully planned programme of co-ordinated scientific research, which can most easily be controlled by one central authority for All-India, leaving to the separate provincial governments the task of administering the fishery laws and regulations. It is further of opinion that, unless development of the fishery resources of Indian waters is carried out with due regard to the scientific principles which form the basis of successful fishery developments, there will be grave danger of irreparable damage to the fisheries concerned.

*Section of Zoology and Entomology.*

A resolution was passed at a joint meeting of the Sections of Zoology and Entomology, urging that fuller facilities for the teaching of Entomology should be provided by the Indian Universities. The Executive Committee have requested Mr. M. A. Hussain to draft a fairly detailed covering letter in support of the resolution which it would forward to the Universities in India.

*Section of Anthropology.*

In a motion by Prof. H. J. Fleure, F.R.S., and seconded by Prof. E. von Eickstedt the following resolution was adopted unanimously:

This conference is of opinion that in view of the urgent necessity of an intensive study of biological traits and social institutions of primitive as well as of advanced peoples and cultures in India, it is essential that the Universities and provincial administrations should make adequate provisions for the teaching of and research in anthropology, including genetics and demography.

That in order to promote such work, the Central Government be requested to give an independent status to Anthropology as a Department of Research.

The Executive Committee has requested Dr. B. S. Guha to draft a statement in support of the resolution which would be forwarded by it to the various authorities concerned.

*Section of Psychology.*

The sub-committee appointed by the Psychology Section to consider the question of the foundation of an all-India Institute of Applied Psychology, had decided that the foundation of such an Institute was at present premature, but recommended that steps should be taken to emphasize the desirability of studying industrial psychology at different centres, and requested the Executive Committee to write to the Universities in India in this connection.

The decision of the sub-committee was accepted and it was decided to request Dr. G. Bose to draft a reasoned statement for the use of the Executive Committee in approaching the different Universities.

## II. RULES AND REGULATIONS, INDIAN SCIENCE CONGRESS ASSOCIATION

### RULES.

1. The name of the Association shall be the Indian Science Congress Association, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including :—

(*a*) the holding and management of funds and property ;
(*b*) the acquisition of rights and privileges necessary or convenient for the object of the Association ;
(*c*) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members and Session Members.

3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.

4. The annual subscription of Ordinary Members shall be Rs. 10. The subscription shall become due on the 1st February of each year, and shall only be effective as a payment for Ordinary membership subscription if received before the 15th July of the year.

5. Any Ordinary Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs. 150.

6. There shall be three classes of Session Members :—

(*a*) Full Session Members—Subscription Rs. 10 per Session.
(*b*) Associate Session Members—Subscription Rs. 5 per Session.
(*c*) Student Session Members—Subscription Rs. 2 per Session.

7. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members provided such papers be communicated through an Ordinary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

8. The official year of the Association shall commence from the 1st of February.

9. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.

10. Only Ordinary Members shall hold office in the Association.

11. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

12. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions

as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

13. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer (who shall be the Treasurer of the Royal Asiatic Society of Bengal for the time being), the Managing Secretary (who shall be the General Secretary of the Royal Asiatic Society of Bengal for the time being), and five Ordinary Members elected by the General Committee. For the purpose of this election any Ordinary Member may propose the name of an Ordinary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

14. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

15. There shall be a General Committee which shall consist of all Ordinary Members of the Association.

16. The General Committee shall meet at least once during each Session of the Congress preferably in the middle of the Session.

17. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary Members of the Association as have held office as President, General Secretary, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition five Ordinary Members of the Association elected by the General Committee. For the purpose of this election any Ordinary Member may propose the name of an Ordinary Member for election to the Council. Such proposal must be seconded by another Ordinary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

18. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

19. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

20. There shall be two General Secretaries who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

21. The term of office of each General Secretary shall be for a period of five years following the confirmation of his appointment and he shall be eligible for re-appointment.

22. In the event of a vacancy amongst the General Secretaries occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary for the period up to the termination of the next Session of the Congress.

23. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

24. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

25. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

26. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee. It shall be competent for any section after the first day's meeting to hold its scientific meetings in sub-sections for the purpose of dealing separately with different groups of papers submitted to that section. A separate chairman may be appointed by the Sectional President in consultation with the Sectional Committee to preside over each sub-section.

27. There shall be in each Section a President and a Recorder who shall be appointed by the Executive Committee. In addition there shall be a Sectional Correspondent and a Local Sectional Secretary who shall be appointed by the Executive Committee.

28. In each Section there shall be Sectional Officers, namely, a President, a Recorder, a Sectional Correspondent, and a Local Sectional Secretary. The President and the Recorder shall be the chief executive officers of the Section. They shall have power to act on behalf of the Sectional Committee in any matter of urgency which cannot be brought before the Sectional Committee for consideration, and they shall report such action to the Sectional Committee at its next meeting.

The work of each Section shall be conducted by a Sectional Committee which shall be constituted as follows:—

(*a*) Sectional Officers.
(*b*) All Ordinary Members of the Association who have been President or Recorder of the Section.
(*c*) Two Ordinary Members of the Association elected by the General Committee at its Annual Meeting during the session of the Congress.

The Sectional President shall preside over all meetings of the Section and of the Sectional Committee. He shall be the convener of the meetings of the Sectional Committee. His ruling shall be final on all points of order that may arise.

The Sectional Recorder shall act as the Secretary of the Sectional Committee, and shall maintain a proper record of the proceedings of the Sectional Committee and of the Section in a book provided for the purpose. He shall be responsible for the punctual transmission to the General Secretary of the recommendations adopted by the Sectional Committee, and of resolutions adopted by the Section.

The Sectional Correspondent shall be resident at the headquarters of the Association, and shall be responsible for preparing for the press the material relating to his Section, according to the instructions of the Sectional President.

The Local Sectional Secretary shall be resident in the locality where the Annual Session is held, and shall be responsible for all local

arrangements for the work of his Section, and for arranging the Sectional excursions in consultation with the Local Secretaries.

29. The Sectional Committee shall meet on the opening day of each session of the Congress, and daily thereafter during the Session before the meeting of the Section unless otherwise determined at a meeting of the Sectional Committee.

In the absence of the Sectional President from any of its meetings the most senior member of the Sectional Committee present shall take the chair.

In their meeting on the opening day they shall :—

(*a*) nominate a Sectional President and a Sectional Recorder for the ensuing year for the consideration of the Executive Committee ;

(*b*) determine the detailed arrangements for the Sectional meetings ;

(*c*) select the papers to be read and discussed ;

and in their meetings during the session they shall also :—

(*d*) nominate a Sectional Correspondent and a Local Sectional Secretary for the ensuing year for the consideration of the Executive Committee ;

(*e*) determine the contents of the Sectional record in the Proceedings in accordance with Rule 30 (*e*) ;

(*f*) consider means of improving the scientific work of the Section, and make suggestions to the Executive Committee whenever considered necessary.

Nominations by absent members of the Sectional Committee for the election of the Sectional President and Sectional Recorder for the ensuing year shall not be regarded as votes. The suggestions, however, shall be considered and recorded in the minutes of the meeting, which shall be forwarded to the Executive Committee along with the Sectional Committee's nominations.

30. (*a*) Any paper submitted for reading at the session of the Congress shall be forwarded to the President of the Section concerned so as to reach him not later than a date to be fixed from time to time by the Executive Committee.

(*b*) Any paper submitted for reading at the session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) Any paper submitted for reading at the session of the Congress shall be refereed by the Sectional President or by some person or persons appointed by him. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) Only abstracts of papers received by the President before the date fixed by the Executive Committee in accordance with Rule 30 (*a*) shall be printed in Part III of the Proceedings. In exceptional circumstances abstracts of papers received after that date and read before the Section, if specially recommended by the Sectional Committee, may be printed in Part IV.

31. The Proceedings of the Indian Science Congress Association shall be published in one volume in four separate parts, as follows :—

I. To contain the list of officers, the proceedings of the opening meeting (except the General Presidential Address) and all official matter.

II. To contain the Presidential Addresses. To be distributed to those present at the meeting after the addresses have been delivered, and to absent Ordinary and Full Session Members by post after the meeting.

III. To contain the abstracts of papers to be read before the Sections which are received before the date fixed by the Executive

Committee. No abstracts shall be included in this volume from authors who have not already enrolled themselves as Members of the Association. To be distributed in advance of the Meeting to all Members of the Association.

IV. To contain the discussions, late abstracts accepted in accordance with Rule 30 (*e*), the list of members and the index.

32. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association :—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Committee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds' majority of the constituent Members present and voting at the meeting.

(Adopted the 5th January, 1931.
Revised the 5th January, 1935,
the 6th January, 1936 and
the 5th January, 1937.)

## REGULATIONS.

### 1. Sectional Officers.

(1) The President delivers a Presidential address which should not take more than one hour to deliver. The manuscript of the address, ready for the press, should be sent to the General Secretary before the 15th November. It should be accompanied by 12 copies of a short popular summary (about 500 words) for issue to the lay press. The time and date of the delivery of the President's address will be communicated before the meeting of the Congress. No two Presidential addresses will be delivered at the same time.

(2) The President shall be entitled to receive 30 copies of his address without charge, and additional copies at the cost of reproduction.

(3) Railway fares, postage, clerical, or other expenses incurred by the Sectional Presidents will not be paid by the Association.

(4) The following procedure is adopted for the collection of papers for the Sections :—

About the middle of April a number of copies of a printed circular will be forwarded to the President of each Section who may arrange

to send these to workers in that branch of science with which his Section is concerned, requesting them to contribute papers for reading before the next meeting of the Congress.

The circular will contain a clause inviting such workers as are not yet Ordinary Members of the Association to join as such. Particular note should be taken of the fact that no new Ordinary Members are enrolled after the 15th July of the year.

In the case of joint papers, each author must be a Member of some category.

(5) The President referees, either in person or by proxy, the papers received for reading before his Section in accordance with Rule 30. Papers which are sent direct to the General Secretary by the authors will be forwarded to the President concerned. No abstracts will be printed unless received through the President.

Abstracts should be limited, except in very special cases, to about 200 words. Long abstracts should be reduced by the President. References to literature in abstracts should be avoided as far as possible and when given should conform to the system of abbreviations used by the Association.

The contents of all abstracts should be carefully edited by the President, who has a completely free hand in the matter.

Joint discussions on related papers may be held. Authors of papers should be informed of the time allotted by the President to the reading of their papers. An author contributing more than one paper should be asked to specify which of them he would prefer to read at the meeting.

(6) The President, in consultation with the Local Sectional Secretary, shall make arrangements for such local sectional excursions as seem desirable. Due notice shall be given to the General Secretaries of all such arrangements.

(7) The President and Recorder should, in consultation with other members of the Sectional Committee, make proposals to the General Secretary regarding the programme of the Section. Such proposals should reach the General Secretary not later than the 1st November, so as to enable the necessary details to be entered in the programme. General discussions on questions of importance, held either by a single Section or jointly by two or more Sections, should be encouraged. Arrangements for discussions should be made well in advance of the meeting, and abstracts of what the principal participants intend to say should be sent to the General Secretary along with the abstracts of papers. Full reports of such discussions should be sent to the General Secretary within three weeks of the termination of the Session for publication in the Proceedings of the Association.

(8) Early in December copies of a printed form will be issued to Presidents for transmission to members of their Sectional Committee, requesting them to nominate a President for the ensuing year for the consideration of the Sectional Committee in accordance with the last paragraph of Rule 29.

(9) The duties of the Sectional Correspondent and of the Local Sectional Secretary are given in Rule 28.

(10) All persons entitled to be members of the Sectional Committee should enrol themselves without delay as Ordinary Members if not already so enrolled and should inform the General Secretary of the payment of their subscriptions when accepting the appointment.

(11) The General Secretary should be consulted whenever any question arises not dealt with in these regulations.

## II. Local Arrangements.

In accordance with the Rules of the Association, the Local Secretaries and the Local Committee shall jointly, on behalf of and in consultation

with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

The following arrangements have to be made:

*A. Accommodation for the Scientific Meetings.*

(1) A large hall should be available for (*a*) the President's address on the opening day, and (*b*) for the evening lectures. Both (*a*) and (*b*) are open to the public free of charge. A projection lantern with an operator should be available in this room, and it is a great advantage if loud speakers can be installed.

(2) Rooms for the meetings of the different Sections of the Congress should be provided and suitably furnished. An epidiascope with an operator should be provided in each sectional room. All the rooms should as far as possible be in close proximity. The following are the sections of the Congress :—

Mathematics and Physics, Chemistry, Geology and Geography,[1] Botany, Zoology, Anthropology, Agriculture, Medical and Veterinary Research, Physiology and Psychology.

(3) A Reception room should be provided in which Members can get information, write letters, etc The Local Secretaries' Office should be as near as possible to this room. An arrangement should be made with the Postmaster-General to have a temporary Post Office in this room and for all letters addressed to members c/o The Indian Science Congress to be delivered here. The Indian Science Congress Post Office should be situated as near as possible to the Reception room.

(4) A room near the Reception room should be set apart for the General Secretaries' office, which will be opened therein from the 31st December.

(5) Provision should be made for lunch in European and Indian styles at moderate charges near the Reception room.

*B. Accommodation for Visiting Members.*

The Local Secretaries should send out, not later than the end of November, a printed circular to all Members enrolled, asking them if they desire that accommodation should be arranged for them. It is desirable, as far as possible, to provide private hospitality for the President, Sectional Presidents, and Officers of the Congress. In this circular information should be given regarding the types of accommodation available, with the charges, and the nature of the climate during the session. The Local Secretaries will receive periodically from the Managing Secretary lists of Members enrolled at headquarters.

*C. Programme of the Meeting.*

(1) The Sections of the Congress meet daily in the mornings generally from 9-30 A.M. Symposia or joint discussions will be held either in the morning, or from 2 P.M.

(2) Public lectures are arranged by the Executive Committee, and are given at 6 P.M. or 6-30 P.M.

(3) A printed guide with a map of the locality in which the Congress is held should be prepared for distribution to Members on the opening day. Only Ordinary and Full Session Members are entitled to the Guide Book free of cost. A small charge not exceeding Re. 1 (to be fixed by

[1] The Executive Committee has accepted the recommendation of the Sectional Committee of Geology and Geography to create two Sections instead, namely, Geology, and Geography and Geodesy.

the Local Committee) may be made to other Members desiring to have a copy. The Guide Book should contain a summary of information concerning the scientific and educational activities and a short history of the locality, in addition to general information likely to be of use to visitors.

(4) Arrangements should be made for giving due publicity to the activities of the Congress, both before and during the meeting.

(5) A list of Members with their local addresses where known should be printed and distributed on the opening day. A supplementary list should be typed and posted in the Reception room and maintained up to date. The Local Secretaries shall arrange for this.

(6) A provisional programme of social engagements should be drawn up by the Local Secretaries and sent to the General Secretary by the 25th November. It is essential that this be sent in time, as it has to be printed and distributed with the abstracts by the first week in December.

The General Secretary will make arrangements for printing the programme drafted as above and distributing these to Members enrolled at the time of the distribution of the abstracts.

The final programme shall be printed locally by the Local Committee in time for the opening of the Session.

### *D. General.*

(1) Numbered badges for Members of the Congress will be sent by the Managing Secretary to the Local Secretaries for distribution on the opening day of the meeting. The badges should bear numbers corresponding to the enrolment numbers. There should be additional badges for Officers.

(2) Members of the Local Reception Committee who have made substantial contributions to the funds of the Local Committee may be given complimentary tickets to attend the meetings.

(3) An audited copy of the accounts of the Local Committee should be sent to the General Secretary not later than the 30th April, following the Session, for inclusion in the Proceedings of the Session. It is desirable that the Local Committee should contribute any surplus to the reserve fund of the Association.

(4) Twelve copies each of all local publications connected with the Congress (guide book, final programme, notices, cards, etc.) should be sent to the office of the Association for record at the conclusion of the meeting

(5) Applications for membership will ordinarily be dealt with by the Managing Secretary at the office of the Association up to the 15th December. After that date applications for membership will be forwarded to the Local Secretaries, who will open a separate account for the sale of membership tickets. The amount thus realized, together with unsold tickets, should be forwarded to the Managing Secretary immediately after the close of the Congress.

(Adopted the 5th January, 1937.)

# I.

## The Indian Science Congress Association.

*Receipts and Payments Accounts for the 11 Months ended 30th November, 1937.*

### Receipts.

| | Rs. | A. | P. | Rs. | A. | P. |
|---|---|---|---|---|---|---|
| To Balance on 1st January, 1937— | | | | | | |
| Investments—4% Loan 1960–70 for Rs. 10,000 at cost .. | 11,416 | 10 | 0 | | | |
| With Imperial Bank of India on Current Account .. | 6,956 | 8 | 8 | | | |
| In hand with the General Secretary .. .. | 50 | 1 | 9 | | | |
| | | | | 18,423 | 4 | 5 |
| „ Members' Subscriptions .. .. | | | | 13,907 | 3 | 0 |
| „ Life Membership Fees .. . | | | | 150 | 0 | 0 |
| „ Annual Contribution from Bombay University .. .. . | | | | 500 | 0 | 0 |
| „ Interest on Investments .. .. | | | | 399 | 0 | 0 |
| „ Miscellaneous Receipts .. .. | | | | 1 | 1 | 0 |
| „ Grants for the Celebration of the Silver Jubilee— | | | | | | |
| Government of India .. | 20,000 | 0 | 0 | | | |
| do Bengal .. | 10,000 | 0 | 0 | | | |
| do Travancore .. | 1,000 | 0 | 0 | | | |
| Universities .. .. | 8,000 | 0 | 0 | | | |
| Private Firms .. .. | 2,850 | 0 | 0 | | | |
| Institutions .. .. | 2,725 | 0 | 0 | | | |
| Members .. .. | 3,939 | 10 | 0 | | | |
| Miscellaneous .. .. | 100 | 12 | 0 | | | |
| | | | | 48,615 | 6 | 0 |
| Total .. .. | | | | 81,995 | 14 | 5 |

### Payments.

| | Rs. | A. | P. | Rs. | A. | P. |
|---|---|---|---|---|---|---|
| By Printing Charges .. .. .. | | | | 3,655 | 7 | 0 |
| „ Postage .. .. .. | | | | 1,516 | 13 | 9 |
| „ Contingencies .. .. .. | | | | 109 | 2 | 0 |
| „ Salaries .. .. .. | | | | 561 | 4 | 0 |
| „ Indexing .. .. . | | | | 84 | 0 | 0 |
| „ Stationary . .. .. | | | | 141 | 6 | 3 |
| „ Audit Fee .. .. .. | | | | 50 | 0 | 0 |
| „ Travelling .. .. .. | | | | 177 | 10 | 0 |
| „ Contributions— | | | | | | |
| Current Science . .. | 250 | 0 | 0 | | | |
| Indian Science News Association .. . | 250 | 0 | 0 | | | |
| | | | | 500 | 0 | 0 |
| „ Passages— | | | | | | |
| British Delegates .. | 43,490 | 10 | 0 | | | |
| Foreign .. .. | 2,537 | 15 | 6 | | | |
| | | | | 46,028 | 9 | 6 |
| „ Balance on 30th November, 1937— | | | | | | |
| Investments—4% Loan 1960-70 for Rs. 10,000 at cost .. | 11,416 | 10 | 0 | | | |
| „ With Imperial Bank of India on Current Account .. | 17,754 | 15 | 11 | | | |
| | | | | 29,171 | 9 | 11 |
| Total .. .. | | | | 81,995 | 14 | 5 |

Examined with the Books and Vouchers and found in accordance therewith.

Price, Waterhouse, Peat & Co.
*Auditors.*
*Chartered Accountants,*
*Registered Accountants.*

*Calcutta,*
*23rd December*, 1937.

S. L. Hora,
*Honorary Treasurer.*

# II.

## Indian Science Congress Association.

*Twenty-fifth Session, Calcutta, 1938.*

**Silver Jubilee.**

*Statement of Receipts and Payments of the Local Reception Committee.*

**Receipts**

| | Rs. | A. | P. | Rs. | A. | P. |
|---|---|---|---|---|---|---|
| Donations— | | | | | | |
| H. E. the Governor of Bengal | 500 | 0 | 0 | | | |
| University of Calcutta | 2,500 | 0 | 0 | | | |
| Others | 17,086 | 0 | 0 | | | |
| | | | | 20,086 | 0 | 0 |
| Excursion— | | | | | | |
| Outside | 1,540 | 0 | 0 | | | |
| Local | 168 | 0 | 0 | | | |
| | | | | 1,708 | 0 | 0 |
| Reservation of Residence | | | | 1,231 | 7 | 0 |
| Stall Rent from Exhibitors | | | | 1,170 | 0 | 0 |
| Advertisement | | | | 955 | 0 | 0 |
| Luncheon | | | | 143 | 8 | 0 |
| Dinner | | | | 259 | 0 | 0 |
| Meal Tickets | | | | 23 | 0 | 0 |
| Miscellaneous | | | | 108 | 10 | 3 |
| Suspense | | | | 10 | 0 | 0 |
| Bank Interest | | | | 19 | 10 | 6 |

**Payments.**

| | Rs. | A. | P. | Rs. | A. | P. |
|---|---|---|---|---|---|---|
| Opening Ceremony | | | | 1,346 | 3 | 0 |
| Meeting Arrangements | | | | 2,923 | 11 | 6 |
| Publication of Descriptive Book of Calcutta | | | | 2,783 | 12 | 3 |
| Printing & Typing Charges | | | | 1,887 | 2 | 3 |
| Postage & Telegram | | | | 460 | 1 | 6 |
| Congress Dinner | | | | 2,676 | 13 | 0 |
| University Party | | | | 1,791 | 6 | 0 |
| Steamer Party | | | | 1,715 | 0 | 0 |
| Luncheon | | | | 761 | 0 | 0 |
| Excursion— | | | | | | |
| Outside | 1,613 | 7 | 3 | | | |
| Local | 311 | 1 | 3 | | | |
| | | | | 1,924 | 8 | 6 |
| Establishment | | | | 1,054 | 15 | 3 |
| Conveyance | | | | 1,181 | 10 | 9 |
| Refund of Reservation Deposit | | | | 220 | 0 | 0 |
| Volunteers' Expenses | | | | 1,448 | 14 | 6 |
| Musical Soiree | | | | 674 | 0 | 0 |

| Receipts | Rs. | a. | p. | Payments | Rs. | a. | p. | Rs. | a. | p. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Presentation of 'Progress of Science' to Members of the Reception Committee .. .. .. | | | | 619 | 12 | 0 |
| | | | | Residence .. .. .. | | | | 1,021 | 7 | 3 |
| | | | | Cost of Photographs .. .. . | | | | 121 | 0 | 0 |
| | | | | Exhibition .. .. .. | | | | 162 | 13 | 0 |
| | | | | Stationery .. .. .. | | | | 310 | 13 | 0 |
| | | | | Audit Fee .. .. . | | | | 125 | 0 | 0 |
| | | | | Telephone .. .. .. | | | | 76 | 8 | 0 |
| | | | | Miscellaneous .. .. . | | | | 68 | 13 | 6 |
| | | | | Suspense .. .. | | | | 10 | 0 | 0 |
| | | | | Bank charges .. .. . | | | | 10 | 13 | 6 |
| | | | | Balance— | | | | | | |
| | | | | At Bank of Baroda, Ltd. . | 304 | 3 | 0 | | | |
| | | | | With Secretary .. .. | 33 | 14 | 0 | | | |
| | | | | | | | | 338 | 1 | 0 |
| TOTAL .. .. | 25,714 | 3 | 9 | TOTAL .. .. | | | | 25,714 | 3 | 9 |

We have audited the Statement of Receipts and Payments of the Local Reception Committee, Indian Science Congress Association, Twenty-fifth Session, Calcutta, 1938 (Silver Jubilee) with the books and vouchers and have obtained all the information and explanations we have required and we certify the same as correct and in accordance with the books.

ANIL GHOSH & CO.,
*Auditors,*
*Govt. Diplomaed Accountants,*
*Registered Accountants.*

S. C. LAW,
*Hony. Treasurer.*

S. K. MITRA,
B. M. SEN,
*Local Secretaries.*

10, *Old Post Office Street,*
*Calcutta, the* 9*th September*, 1938.

# Proceedings of the Twenty-fifth Indian Science Congress

## PART II—PRESIDENTIAL ADDRESSES

## CONTENTS

# *Inaugural Address*

*Congress President* :—SIR JAMES JEANS, D.Sc., Sc.D., LL.D., F.R.S.

Until a very few weeks ago, we had hoped to assemble here under the Presidency of one of the greatest scientists of all time, and it is inevitable that his sudden and tragic death should be uppermost, not only in the thoughts of those of us who come from Europe, most of whom knew him personally, but in the thoughts of everyone here. For his works had made him known to us all. He has been cut off in the fulness of his powers —leaving as his monument a rich and full life's work, such as few men have equalled, but also leaving a feeling that he might have accomplished more, and possibly even greater, things had he been left with us a few years longer.

Those of us who were honoured by his friendship know that his greatness as a scientist was matched by his greatness as a man. We remember, and always shall remember, with affection his big, energetic, exuberant personality, the simplicity, sincerity and transparent honesty of his character, and, perhaps most of all, his genius for friendship and good comradeship. Honours of every conceivable kind had been showered upon him, so that he could not but know of the esteem in which he was held by the whole world, and yet was always simple, unassuming and ready to listen patiently to even the youngest and most inexperienced of his pupils or fellow-workers, if only he were honestly seeking for scientific truth.

This is neither the place nor the occasion to attempt any detailed description of his scientific achievements. A great physicist, Niels Bohr—whom we are sorry not to have with us here—speaking of Rutherford's work to a congress of physicists which recently met in Bologna, said : 'His achievements are so great that, at a gathering of physicists like the one here assembled, they provide the background of almost every word that is spoken '. As it was in Bologna, so it will be in Calcutta ; the proceedings in our physics section will be utterly different from what they would have been had Rutherford not lived and worked. And it is sad to think that they will be utterly different from what they would have been had he lived even a few months longer, for then we should have had his ardent and inspiring personality and vast fund of knowledge and experience to direct and enliven our debates. Happily he will not be altogether absent from our meeting. He had been looking forward with the greatest interest and eagerness to this occasion, and had

already written a Presidential address for it, which it will be my duty to read to you very shortly.

In this he tells us, in his own words, of his latest work of all—that in nuclear physics, and especially in what he described as 'the new alchemy', the transmutation of the elements. This alone would have ensured him a place in the foremost rank of physicists, and yet it formed only a small part of the total achievement of his life.

When I first knew him, almost exactly forty years ago, he was experimenting in wireless telegraphy, using a detector of his own invention, and transmitting signals to what was, for those times, the record distance of about a mile and a half.

That was in the period which he used himself to describe as 'the heroic age of physics'. Within the space of a very few years, Röntgen rays were discovered and provided a new line of attack on the problems of electric conduction in gases; the electron was isolated, and seemed to point the way to an understanding of the age-long puzzle of the structure of matter; radio-activity was discovered, with its apparent violation of well-established physical laws, and opened up a new road which led no one knew where—but obviously into very different territory from that which nineteenth century physics had so industriously and thoroughly explored.

Rutherford directed his colossal energy and tireless enthusiasm on to all these vast new problems in turn. By a few investigations of masterly simplicity, he reduced the puzzling phenomena of radio-activity to law and order, and, in collaboration with Soddy, discovered the physical interpretation of this law and order. Radio-activity, they found, indicated the transmutation of one element into others through processes of spontaneous atomic explosion.

Rutherford then treated the $\alpha$-particles which were emitted at these radio-active explosions as projectiles. He bombarded atoms with them and in so doing discovered the composition of the atoms. Finally he shewed how similar bombardments could change the constitution of the atomic nuclei, and so literally transmute the elements; the dream of the alchemists was realized.

These were perhaps the outstanding landmarks in his career, but in truth most of his investigations were key investigations, each brilliant in its simplicity of conception, masterly in its execution and far-reaching in its consequences. His output of work was enormous and can only be explained by his capacity for delegating all the less important details of an investigation to a collaborator, whom he usually inspired with his own enthusiasm. In his flair for the right line of approach to a problem, as well as in the simple directness of his methods of attack, he often reminds us of Faraday, but he had two great advantages which Faraday did not possess—first, exuberant

bodily health and energy, and second, the opportunity and capacity to direct a band of enthusiastic co-workers. Great though Faraday's output of work was, it seems to me that to match Rutherford's work in quantity as well as in quality, we must go back to Newton.

Voltaire once said that Newton was more fortunate than any other scientist could ever be, since it could fall to only one man to discover the laws which governed the universe. Had he lived in a later age, he might have said something similar of Rutherford and the realm of the infinitely small; for Rutherford was the Newton of atomic physics. In some respects he was more fortunate than Newton: there was nothing in Rutherford's life to compare with the years which Newton spent in a vain search for the philosopher's stone, or with Newton's output of misleading optical theories, or with his bitter quarrels with his contemporaries. Rutherford was ever the happy warrior—happy in his work, happy in its outcome, and happy in its human contacts.

Through the tragic circumstance of his death, I stand before you as your President. I cannot tell you how greatly honoured I feel by your choice, but neither can I tell you how strongly I feel my utter inadequacy to act as substitute for the really great man we had all hoped to have with us here.

Yet I must not forget that I am here in a second capacity also—as spokesman of the Delegation from the British Association. It so happened that I was President of the Association in 1934, when we received your invitation to join you in Calcutta, and I vividly remember how anxious your representatives were to do everything possible to make our visit not only scientifically fruitful, but also pleasurable to ourselves.

I am sure I speak for the whole of the European deputation in thanking you once again for your lavish and carefully-planned hospitality.

To some of us—but only a few—India is well-known territory; others—I think the majority—come here for the first time. But we all feel a special interest in being here for the 25th Anniversary of your Indian Association. The quarter-century of your existence has been a period of stupendous developments in almost all branches of science, and certainly not least in those which have formed my own field of work. Twenty-five years ago the astronomers were still debating as to whether the great spiral nebulæ were inside the galactic system or outside; estimates of the distances of these nebulæ differed by factors of at least 100, and the vast universe of extra-galactic astronomy was still closed territory. The genius of Einstein had already given us the restricted theory of relativity—the simple physical theory which grew out of the Michelson-Morley experiment—but the more complex gravitational theory was still unborn, and we were still perplexed by its puzzles as to whether the

universe was finite or infinite, and whether space and time were real or unreal. In physics, Planck had given us the rudimentary quantum-theory which was required by the phenomena of black-body radiation, but its application to atomic physics was yet to come. Rutherford's epoch-making investigation on the scattering of $\alpha$-particles by atoms had just, but only just, shewn us the atom as we see it today—the heavy nucleus with the cloud of light electrons surrounding it. Bohr immediately seized upon this concept and developed it further; he shewed how the quantum theory could be applied to the movements of this cloud of electrons, and made it yield an interpretation of atomic spectra. On this basis were built first the old quantum-theory and then the far vaster structures of the new quantum-theory and the wave-mechanics. Finally the new science of nuclear physics came into being, largely as a personal creation of Rutherford; his very last utterance on this subject was written especially for you, and in a few minutes I shall be reading it to you.

Nor has India stood idly by as a mere spectator of this most thrilling period in the history of science. These twenty-five years have not only seen your association increase from infinitesimal beginnings to its present international importance; they have also seen the phenomenal growth of India as a scientific nation. In 1911 there were no Indian-born fellows of the Royal Society; to-day there are four. In 1911 the Royal Society published no papers by Indians, in 1936 we published ten. Yet statistics are dry things, and even those which shew an infinity-fold increase convey a less vivid picture than a few concrete examples, such as each of us can find in abundance in his own subject. The mathematicians and physicists will probably find their thoughts turning, as mine do, to the strangely intuitive genius of Ramanujan and to the remarkable discoveries he had made in pure mathematics before death snatched him prematurely away: to the work of Sir Venkata Raman in physics, and especially his discovery of the effect which is known by his name all the world over; to many investigations in sound and the theory of music made by Raman and a host of others; to the work of Saha in astrophysics, which gave us our first clear understanding of the meaning of stellar spectra, and so unlocked the road to vast new fields of astronomical knowledge; and to the work of many Indians, among whom I would specially mention Chandrasekhar and Kothari, on conditions in the interiors of the stars. And I am sure that not only the mathematicians and physicists, but workers in all other fields as well, will be thinking with admiration of the remarkable ingenuity and experimental skill shewn by that great Indian scientist, the late Sir Jagadis Chunder Bose.

If such names and achievements as these come into the mind of a worker in one only of the many vast fields of science,

we can form some slight idea of the richness of India's contribution to science as a whole. Thinking on this great contribution, we of the British Association congratulate you of the Sister Association most whole-heartedly, not only on the completion of your twenty-five years of existence, but even more on the wealth of harvest you have gathered in that twenty-five years.

# *Presidential Address*[1]

*Congress President-Elect:—*

PROF. THE RT. HON. LORD RUTHERFORD OF NELSON,
O.M., F.R.S., D.Sc., LL.D., Ph.D.

During the past fifty years, the British Association for the Advancement of Science has been invited on many occasions to hold its meetings overseas. Four times it has journeyed to Canada (Montreal 1884, Toronto 1897, Winnipeg 1909, Toronto 1924), twice to South Africa (1905, 1929), once to Australia (1914). This policy of the Association of arranging occasional meetings in our Dominions has proved an unqualified success. These overseas visits have had a marked influence on the progress of science throughout our Commonwealth and by personal contacts have helped much to promote mutual understanding and co-operation between our peoples.

The visit of a representative group of scientific men to our most distant Dominions in 1914, in itself an outstanding event in the history of the Association, was rendered even more notable by the dramatic circumstances under which the meetings were held, for the arrival of the party in Australia coincided with the news of the outbreak of the Great War. No one who like myself took part in the meetings in Australia and New Zealand in those troubled but stirring times can ever forget the warmth of our reception. We were privileged to witness that wonderful response of the peoples of these lands to the call of danger—a response which we know grew ever greater with the need.

It has long been the wish of the British Association to hold a meeting in India, but difficulties of time and climate have stood in the way of its realization. It has been found most convenient for the overseas visits to take place in the summer months but such a time is quite unsuitable for India. This difficulty would be in part surmounted if a representative party of scientific men could obtain leave of absence from their duties to visit India during the cold weather.

The celebration of the Silver Jubilee of the founding of the Indian Science Congress Association offered a suitable occasion for such a visit, and arrangements have been made by the two Associations to hold a joint meeting in India. I gladly accepted the invitation of the two bodies to preside over this combined meeting. I feel it not only a great honour but a

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[1] Received after Lord Rutherford's death.

great privilege and responsibility to be asked to fill this post on such an historic occasion. This visit of the British Association to your shores is a symbol of our desire to extend the hand of greeting and fellowship to our sister society and also individually to our co-workers in science in India.

While science has no politics, I am sure it is of good omen that our visit happens to fall at a time when India is entering upon a new and important era of responsible co-operative government in the success of which both our countries are deeply concerned.

On behalf of the British Association, I extend to the Indian Association our warmest congratulations on this the twenty-fifth anniversary of its foundation and our sincere wishes for its continued success. We recognize that your Association, both in its constitution and its aims so closely resembling the British Association, has proved of great service to the progress of science throughout India. Founded at a time when the Universities were becoming centres of original research, it afforded to a widely scattered scientific community a much needed common meeting ground for the discussion of scientific problems. It helped also to bring to the attention of the interested public the importance of science and of the scientific method in national development. I think it can be safely stated that the success of the meetings of the Indian Association in no small degree influenced the later foundation of specialist societies in India, for example, the Chemical Society and Physics Society.

On such an occasion as this, we must not forget to do honour to those who were largely instrumental in founding your Association and in guiding its infant steps. I would refer in particular to Professor J. L. Simonsen, Professor P. S. MacMahon and your senior Past-President, Sir Sydney Burrard. The Association owed much in its early days to the friendly support and encouragement so freely given by that premier Indian Society, the Royal Asiatic Society of Bengal of which I am proud to be an honorary Fellow.

In earlier days in India, research was largely confined to the great official scientific services, initiated and maintained on a generous scale by the Indian Government, for example, the Survey of India, the Geological Survey, the Botanical Survey, the Departments of Agriculture and Meteorology and many others. Pioneer work of outstanding scientific importance has been done by all these services. In the short time at my disposal, I can only make a passing reference to a few items of work accomplished, and can mention only a few of the array of distinguished names which have been connected with these great scientific services.

The Trigonometrical Survey of India has a long and distinguished history. The splendid series of geodetic measurements along an arc from Cape Comorin to the Himalayas, made by

Everest, was of outstanding importance and his name is for ever associated with the highest peak in the world. As a result of this survey, the deflections of a plumb line, due to the gravitational attraction of the Himalayan range, were determined at different points. A careful comparison of the results of observation with calculation, largely due to the work of Archdeacon Pratt of Calcutta, and later of Sir Sydney Burrard, disclosed marked discrepancies, the effect of the mountain mass at a distance being much less than was expected. Attempts to explain these and other anomalies ultimately led to the formulation of a new and important theory of mountain formation known as the principle of isostasy. On this hypothesis, the excess pressure due to a mountain mass is compensated for by a deficiency of matter below its base. This conclusion, which is in accord with extensive gravitational as well as geodetic measurements in India, is believed to be of general application to mountain formation throughout the world.

I may recall that a former distinguished Superintendent of this Survey, Sir Gerald Lenox Conyngham, is now Head of the Department of Geodesy in Cambridge.

The Geological Survey, one of the oldest scientific services in India, has a fine record of work accomplished and its survey of the mineral resources of India has proved of great value to Indian industry. Among many distinguished names, I may specially mention that of Sir Thomas Holland, a former Director, who has done such good work for your country in peace and war. I believe that it was largely due to his energy and scientific insight that the great Tata Iron and Steel Works were begun.

The Department of Meteorology has done much pioneering research and was one of the first to realize the importance of studying the conditions of the upper air by means of small balloons—a subject of ever-increasing importance with the advent of the aeroplane. I have always felt a friendly interest in this Department as many of its members are known to me personally. Amongst them is Sir Gilbert Walker, a former Director and once President of this Association, who did much to improve the Meteorological Service in India and himself made important original contributions to our knowledge of the South-West Monsoon. I may recall that the present distinguished head of the Meteorological Office of Great Britain, Sir George Simpson, was for many years a member of this Indian Department.

The study of the botanical riches of India owes much to the work of Roxburgh, Wallich and Prain, and also that explorer and naturalist, Hooker, whose work on the flora of British India is known to you all.

In Forestry, India has at Dehra Dun probably the finest research laboratory of its kind in the world. We in England owe a debt of gratitude to India in providing us with our distinguished Professor of Forestry at Oxford, Professor R. S. Troup,

and the first two directors of our Forest Products Laboratory, namely Sir Ralph Pearson and Mr. W. A. Robertson.

While in this brief survey I can mention only a few departments out of many, yet I must not omit to refer to the great advances in knowledge due to the Indian Medical Service, so well represented by the pioneer work of Ross on malaria and by Leonard Rogers on cholera and leprosy, researches which gave new hope to the peoples of India.

In the early days of the Indian Universities, attention was mainly directed to teaching and examining the large number of students who presented themselves, and comparatively little attention was paid to research. There were always a few, however, who recognized that the universities had a wider part to play in Indian education, and should become centres of research as well as of teaching. Amongst those pioneers who distinguished themselves by original investigations and by the stimulation of others, I should particularly mention Sir Alexander Pedler, Sir Alfred Bourne, Sir Jagadis Bose and Sir Prafulla Ray, and it is of interest to recall that the last three have all been presidents of your Association.

As a result of the Curzon Commission on Education in 1904, many of the universities introduced honours courses, and by new appointments and improvements in laboratories stimulated research in science. Excellent well-equipped schools of research have arisen in many Indian universities, where good opportunities are available for the training of potential investigators in the methods of research. The Indian student has shown his capacity as an original investigator in many fields of science, and, in consequence, India is now taking an honourable part and an ever-increasing share in the advance of knowledge in pure science.

Amongst many workers of distinction, I may specially mention Sir Venkata Raman, Professor M. N. Saha and Professor B. Sahni, each of whom has made outstanding contributions. That premier scientific society of Great Britain, the Royal Society, has recognized the value of their work by election to its Fellowship.

We in Great Britain watch with pride this growth of the scientific spirit in India and are pleased to help in any way we can. As an example of our interest, I may recall that Trinity College, Cambridge—my own college—assisted that mathematical genius Ramanujan to prosecute his studies in Cambridge. He was soon elected a Fellow of that College and a Fellow of the Royal Society. But for his premature death, it may be said of him, as Newton said of Cotes, that we had known something.

The researches in astrophysics of S. Chandrasekhar in Cambridge were soon recognized by the award to him of an Isaac Newton Studentship and later by his election to a Fellowship in Trinity College.

As a member of the Royal Commission for the Exhibition of 1851, I would like to refer to some events this year of special interest to India. This Commission awards each year a number of Overseas Scholarships to our Dominions, as well as Senior Research Studentships open to competition in England by all members of our Commonwealth. The opportunity offered by these scholarships to promising investigators from overseas to continue their work in England or abroad has proved of great value to the progress of science. I am proud to remember that I myself was awarded an 1851 Scholarship on the recommendation of the University of New Zealand.

It has for some time been the wish of the 1851 Commission to be able to offer one or more of its Overseas Scholarships for award to students in India. Owing to difficulties of finance, it was only this year that this project was realized. A preliminary committee of selection was set up in India and the Commissioners with whom lay the final choice have appointed Mr. N. S. Nagendra Nath of the Indian Institute of Science, Bangalore, as the first 1851 Exhibition Scholar from India. He will proceed to Cambridge to carry out investigations in Theoretical Physics. For the first time also, an Indian student in Cambridge, Dr. H. J. Bhabha, has been awarded in open competition one of our valuable Senior 1851 Studentships in recognition of the importance of his researches in Theoretical Physics. The Commission would like to be in a position to allot a second Science Scholarship to India but funds are insufficient. The machinery, however, is there, and I know that the Commissioners would be only too happy to administer a second award if anyone in India, who is interested in her scientific progress, were generous enough to provide the necessary endowment.

While, as we have seen, the universities of India have in later years made substantial progress both in teaching and research in science, yet it must be borne in mind that still greater responsibilities are likely to fall on them in the near future. This is in a sense a scientific age, where there is an ever-increasing recognition throughout the world of the importance of science to national development. A number of great nations are now expending large sums in financing scientific and industrial research with a view to using their natural resources to the best advantages. Much attention is also paid to the improvement of industrial processes and also to conducting researches in pure science which it is hoped may ultimately lead to the rise of new industries.

It is natural to look to the universities and technical institutions for the selection and training of the scientific men required for this development. In India, as in many other countries, there is likely to be a greater demand in the near future for well-trained scientific men. With the growth of responsible government in India, it is to be anticipated that the staff required for

the scientific services in India and for industrial research will more and more be drawn from students trained in the Indian universities. It is thus imperative that the universities should be in a position not only to give a sound theoretical and practical instruction in the various branches of science but, what is more difficult, to select from the main body of scientific students those who are to be trained in the methods of research. It is from this relatively small group that we may expect to obtain the future leaders of research both for the Universities and for general research organizations. This is a case where quality is more important than quantity, for experience has shown that the progress of science depends in no small degree on the emergence of men of outstanding originality of mind who are endowed with a natural capacity for scientific investigation and for stimulating and directing the work of others along fruitful lines. Leaders of this type are rare but are essential for the success of any research organization. With inefficient leadership, it is as fatally easy to waste money in applied research as in other branches of human activity.

The selection of such potential investigators and leaders is not an easy task, for success in examinations in science is no certain criterion that the student is fitted for a research career. A preliminary training in research methods for a year or two is required to select those who possess the requisite qualities of originality and aptitude for investigation. A system of grants-in-aid or scholarships to approved students may be required for such postgraduate training. In Great Britain the financial help given by the Universities and other educational institutions for training in research is in many cases supplemented by maintenance grants to promising students, awarded by the Department of Scientific and Industrial Research. This system has proved of much value both in developing the research activities of the universities and in providing a supply of competent men both for research in pure science and in industry.

I have so far mentioned some aspects of the scientific work carried out by the universities and government services of India. I am well aware that much attention has also been directed to the need of scientific research in agriculture, and in certain industries. An Indian Cotton Committee has been set up which has given admirable service, while the Indian Lac Cess Committee arranges for investigations in that unique Indian product, some of which are carried out in Great Britain. I am interested to know that an Agricultural Research Council has recently been formed, largely as a result of the findings of a Commission of which His Excellency the Viceroy was Chairman.

While I cannot lay claim to have any first-hand knowledge of Indian industries and conditions, yet perhaps I may be allowed to make some general observations on the importance in the national interest of a planned scheme of research in applied

science. If India is determined to do all she can to raise the standards of the life and health of her peoples and to hold her own in the markets of the world, more and more use must be made of the help that science can give. Science can help her to make the best use of her material resources of all kinds, and to ensure that her industries are run on the most efficient lines. National research requires national planning. If research is to be directed in the most useful direction, it is just as important for a nation as for a private firm to decide what it wishes to make and sell. It is clear also that any system of organized research must have regard to the economic structure of the country. One essential fact at once stands out. India is mainly an agricultural country, for more than three-quarters of her people gain their living from the land, while not more than three per cent. are supported by any single industry. A glance at the official review of the trade of India shows that the annual production of wheat has risen since 1914 from about 8·3 to 9·5 million tons, while exports in the same period have fallen from over a million tons to 10,000 tons. In the case of another important food, rice, the Indian production, exclusive of Burma, has remained fairly steady, varying between 22 and 25 million tons annually, but here also exports have fallen from about half a million tons before the War to about 200,000 tons.

In view of these facts, it would seem clear that, in any national scheme of research, research on foodstuffs has a primary claim on India's attention. Quite apart from improvements in the systems of agriculture used in India, there is a vast field for the application of scientific knowledge to the improvement of crops, for example, by seeking for improved strains suitable for local conditions, by research on fertilizers and in many other directions. The fact that surplus wheat for export has decreased suggests that the present production is required for home consumption in India. When the permanent schemes of irrigation now in hand bring much more land under full cultivation, India may again wish to take her place in the export market. To do this in the face of international competition, well-planned agricultural research will be essential.

While the character of India's trade has seen many changes in the last hundred years, to-day exports of cotton, jute and tea amount to about 60 per cent. of the total exports of India. Next in importance come oil and seeds 6 per cent., hides 5 per cent. and lac 1 per cent. There is no doubt that more scientific knowledge would increase the production of all these products. There is of course the need to make sure that there is a market for such a surplus. Of India's standard exports, cotton represents about 20 per cent. of the total value. In spite of recent strenuous attempts to improve Indian cotton, its staple is still usually looked upon in the world's markets as short and coarse. No doubt there are purposes for which cotton of this

type possesses special advantages, though the demand for it must now be very near to saturation point. Still, India only produces about 16 per cent. of the world's cotton crops and there appears to be no reason why it should not produce a larger share; but until the cultivation of better varieties is more extensive, competition with cottons of the American type in the world markets will certainly be difficult. Here there appears to be a wide field for applied research. Good work has been done by the Indian Cotton Committee which has taken steps to improve the staple and prevent adulteration and inter-mixture of various varieties. The problem can be approached, however, not only in the seeking of better varieties but in finding uses and methods of treatment for the short staple variety. The importance of research on the cotton itself is well brought home by the results achieved in the United Kingdom, where the British Cotton Industry Research Association at the Shirley Institute has found that many of the defects which appear in the finished article can be traced back to defects in the raw material.

Finally a word might be said concerning the need for research on radio-communication, so important a matter to a large country like India. I do not refer to technical research in transmitting and receiving apparatus, but rather to the type of fundamental investigation pursued under the Radio Research Board in Great Britain. These investigations, begun in the early days after the War, have shown that the propagation of radio-waves over large distances is very sensitive to the electrical state of the upper atmosphere. It is now established that a number of electrified layers exist in the higher atmosphere which under certain conditions are able to reflect electric waves. The details of this electrical distribution vary considerably with the hour of the day and with the season of the year, as well as with geographical location. Such information, which is of practical importance in the selection of the most suitable wave-lengths for radio-communication, must obviously be secured by research conducted in the country itself. Moreover, it does not seem impossible that such a survey may prove of value in long range weather forecasting.

There is here, then, much scope for research in a wide field, which I hope will be pursued vigorously in India. It is pleasant to note that a most promising beginning in tackling fundamental radio problems of this character has already been made here by Professors M. N. Saha and S. K. Mitra and their students. The importance of survey work of this kind has already been recognized in other parts of the Empire, where it has received official support and encouragement. I will refer in particular to the admirable work in this field by the Radio Research Board of Australia.

### *Industrial Research in Great Britain.*

While I recognize the great differences which exist between the industrial and agricultural conditions in Great Britain and India, yet it may prove of some interest and, I hope, of some value, if I give a brief account of some of the ways in which the British Government has aided industrial and agricultural research in the period following the Great War. From the dawn of the scientific age, Great Britain has taken a prominent place in advancing knowledge both in pure research in our universities and in applied research for the development of industry. Before the War, progress in industry depended in the main on the brilliant contributions of individual workers rather than on any systematic attack by scientific methods on the problems of industry. We may instance the pioneer work of Bessemer for the steel industry and of Parsons in the development of the steam-turbine which had such a great effect on the power-industry. One cannot pay too high a tribute to the greatness of the achievements of individual inventors and investigators such as these, for it was largely due to them that Great Britain obtained so great an industrial position in the last century.

Yet I think it is true to say that in the period before the War the country as a whole failed to recognize as fully as some other nations the importance of an organized scientific attack on broad lines on the problems of industry. In a number of cases, British science gave ideas to the world, but it was left to other nations to develop them by intensive research and to reap the industrial benefit.

This weakness in our organization became apparent in the War when the production of munitions and materials threw a great strain on industry. The common danger brought the industrialist and man of science into close co-operation to their mutual benefit. The results of this co-operation surpassed all expectation. New chemical processes were evolved, many new devices arose, while communications were revolutionized by the rapid development of the thermionic valve. In a hundred different ways, the co-operation of science with industry had justified itself by its success.

Early in the War, the British Government recognized that when peace came, a more systematic application of science and research over a broader field was essential in the national interest and, amid the distractions of war, set up the necessary machinery to accomplish this. In 1915 the Department of Scientific and Industrial Research was formed, and a few years later in 1920 the Medical Research Council was set up to undertake investigations in all matters connected with the health of the people. This was followed in 1931 by the formation of the Agricultural Research Council. The formation of the Department of Scientific and Industrial Research marked the first comprehensive

and organized measure taken in Great Britain to help industry generally through the application of science. A number of new research organizations were set up, controlled and financed by the Department, to deal with the scientific aspects of the use of fuel, of the storage and transport of food, of buildings and later of roads—subjects of great importance to the common welfare of the people but on which little if any organized research had been undertaken.

Coal is the greatest material asset possessed by Great Britain, for on it mainly depends the heating of our homes and the production of power for most industries. Its better utilisation is a problem of great national importance. To achieve this purpose, the Fuel Research Board was formed and a large laboratory was erected at Greenwich to carry out investigations on the better and more economic use of coal. An important section of this work is a national survey of the coal resources of Great Britain carried out in special laboratories in the several coalfields. The properties of the coal in the various seams are carefully examined and, if necessary, full scale trials are made at the Fuel Research Station to test the suitability of the coal, for example, for carbonization, for steam raising or for conversion into oil. The results of this survey, which is still in progress, have proved of increasing value not only to the colliery owner and the industrialist but also for the needs of the export trade.

In Great Britain every year upwards of 100 million pounds are spent on the erection of new buildings and in maintaining old ones, yet no organized research on buildings had been made. To remedy this deficiency, the Department set up a Building Research Station near London where investigations are made on the many and varied problems connected with the better housing of the people. For example, investigations are carried out to find a scientific explanation of the traditional practices which have grown up in the building trade, for on this depends a rational adjustment of materials and methods to meet modern needs. The results of such a scientific enquiry in this comparatively unexplored field cannot fail to have a marked influence on building construction generally.

The Building Research Station embraces in its programme all problems connected with building materials except those associated with the use of timber. These are dealt with at another establishment of the Department, the Forest Products Research Laboratory. Here intensive researches are carried out on the best use of timber and its preservation. The country spends large sums annually on timber, much of it imported, and in the national interest it is of great importance to us that the best value is obtained for this outlay.

You are all aware that food represents one of Great Britain's largest imports, and much of this is transported great distances from overseas. An organization was set up known as the Food

Investigation Board, to consider the best methods of storage and transport of food, so as to avoid waste and loss of nutritive value. Much of this work has its centre at the Low Temperature Research Station in Cambridge, but a special station at Torry, Aberdeen, deals with the preservation of fish and another at Ditton in Kent with the storage of fruit. Investigations in this field, which owe so much to the initiative of the late Sir William Hardy, have proved very valuable in many directions, and have led to great improvements in the conditions of transport and storage of a great variety of food stuffs.

I may give one example out of many of the striking consequences of such researches. The Low Temperature Research Station found that beef in a chilled state could be safely stored for 60 or 70 days in a suitable atmosphere of carbon dioxide. The importance of this discovery, which enabled beef to be carried in first rate condition from our most distant Dominions, was at once recognized by the interests concerned. The first shipment of chilled beef carried by this new method of gas storage was landed in 1929 from New Zealand. Since that time, shipments from Australasia have steadily increased, and most of the vessels built for the Australasian trade have now chambers specially constructed for transport in gas storage.

While the development of our roads in the past owes much to the pioneer work of men like Macadam and Telford, there was no planned organization to add to our knowledge of road construction until comparatively recent years, when the Road Research Station was set up at Harmondsworth near Slough to deal with problems of road construction and the study of road wear under modern conditions of traffic. When we consider the large sums spent every year on the construction and maintenance of roads, the need of such scientific investigation is obvious.

The group of research organizations so far considered deals with the primary needs and interests of the people as a whole as regards food, fuel, building and roads. No independent establishment was set up to deal with another important need of the people, namely clothes, for this is most appropriately provided for by the large research associations which have been instituted in connection with the cotton, wool, and linen industries.

Of the national organizations under the charge of the Department, the largest and probably the most important is the National Physical Laboratory at Teddington, which covers about 50 acres and employs a staff of nearly 700 persons. The work of this Laboratory, primarily intended for the assistance of industry in general, covers a very wide field. It has eight great departments devoted to the study of the different branches of Physics, Electrotechnics, Engineering, Metallurgy and Metrology, Radio-communications, Aero-dynamics and the investigation of ship design. The Laboratory is responsible for the maintenance of the

National Standards and for refined measurements connected with them. It is not always realized to what a great extent modern mass production depends on the maintenance of exact standards and the Laboratory plays an important part in testing the accuracy of gauges so necessary in modern industry.

In 1925 a Chemical Research Laboratory was set up at Teddington, in which pioneer work is being carried out on chemical reactions at high pressures and temperatures and in the production of synthetic resins. Another important problem in which the Department is interested is the provision of more plentiful supplies of pure water for domestic and industrial consumption. Valuable work has been done by the Water Pollution Research Board in many directions, and new methods have been found for the purification of water which has been contaminated by the industrial effluents from sugar and milk factories.

I have so far mentioned research organizations which have been set up to encourage the application of science to problems which affect the daily life of the people and the nation's industries considered as a whole. I should mention that these national organizations to which I have referred are not only willing but anxious to co-operate with corresponding institutions which may be set up in India or the Dominions.

I must now refer to arrangements which have been made to promote the application of scientific knowledge to the problems of the individual industries. The importance of research has long been recognized by large industrial companies, who have in many cases set up research establishments for their own requirements. This tendency is specially marked in the electrical and chemical industries, where large sums are spent annually on research.

It is, however, to be borne in mind that a great part of British industry is carried out in small establishments. A survey carried out some years ago indicated that in 128,000 factories in Great Britain less than 500 employed more than 1,000 workers while over 117,000 employed less than 100 workers. Obviously such small factories are not in a position to maintain a research laboratory on anything but a small and inefficient scale. To overcome this difficulty, the Department in conjunction with industry instituted a number of co-operative research associations representing the greater part of the main industries of the country. Each of these research associations is autonomous and controlled by representatives of the industry concerned, and is financed by contributions from the firms belonging to the association, assisted by grants from the Department.

This bold experiment in the co-operative organization of research, which is unique in the world, has undoubtedly proved a great success. To-day there are twenty such research associations formed on a national basis in their respective industries and for

membership of which all British firms are eligible. They cover the metal and textile industries, paint, leather, boots and shoes, rubber, flour milling, cocoa and confectionery, food, printing, scientific instruments and the automobile and electrical industries. From small beginnings, a number of these associations have steadily grown in size and strength until they now form an indispensable and valuable part of the industries they represent.

I can speak with some knowledge of the marked progress made by these two types of research organization, as I have been privileged, as Chairman of the Advisory Council of the Department of Scientific and Industrial Research for the past 8 years, to come in close contact with them. While much still remains to be accomplished, there has been a great advance in recent years in the recognition of the value of research in increasing the efficiency of industry. If we are to hold our own in face of the ever increasing competition in the world to-day, it is essential that our industries should take full advantage of the resources which science places at their disposal.

It is of interest to note that the Overseas Dominions have not been slow to appreciate the importance of such national organizations in the development of their national resources and industries. Healthy research organizations under the control of National Research Councils or corresponding bodies have been set up in Canada, Australia, New Zealand and South Africa. Both in Canada and Australia, which have a Federal system of Government, the research organization is national in the true sense of the word, and responsible only to the central Government.

It is to be borne in mind that the organization of research for industry and for general national purposes varies much in different countries. A research organization which may prove adequate for a country like Great Britain may prove quite unsuitable for another country with different needs and different industrial conditions. In developing any organized scheme of research, each country must consider its own resources and its own particular requirements. As we have seen, the organization of research not only in Great Britain but in the Dominions, is national in scope. Even in a large country like India, where the resources and needs of the different Provinces are very varied, it seems to me essential for efficiency that the organization of research should be on national rather than on provincial lines. The setting up of separate research establishments for similar purposes in the various provinces cannot but lead to much overlapping of work and waste of effort and money. Such a central organization of research does not necessarily mean that the scientific work should all be concentrated in a single laboratory. For example, I understand that a single organization is responsible for the research in cotton for the whole of India. While the more fundamental research is done at a conveniently situated laboratory, much of the work of a

special character is carried out in the provinces where cotton is grown.

In Great Britain, the responsibility for planning the programmes of research, even when the cost is borne directly by the Government, rests with research councils or committees who are not themselves State servants but distinguished representatives of pure science and industry. It is to be hoped that if any comparable organization is developed in India, there will be a proper representation of scientific men from the universities and corresponding institutions and also of the industries directly concerned. It is of the highest importance that the detailed planning of research should be left entirely in the hands of those who have the requisite specialized knowledge of the problems which require attack. In the British organizations there is no political atmosphere, but of course the responsibility for allocating the necessary funds ultimately rests with the Government.

In this address, I have to a large extent confined my attention to research in pure science, agriculture and industry. I am, however, not unmindful of the pressing needs of India to alleviate the sufferings of the people from attacks of malaria and other tropical diseases. I know that India herself is giving much thought to these vital problems in which science can give her valuable help.

### *Transmutation of Matter.*

I have so far spoken of the importance of science as a factor in national development, but before concluding my address, I would like to refer to some investigations in pure science in which I have been personally much interested. I refer to the successful attack on that age-old problem of the transmutation of matter which in recent years has attracted so much attention from physicists throughout the world.

I hope it may prove of interest to give a brief account of the successive stages of the growth of our knowledge of this subject, for it illustrates in a striking manner the power of the scientific method of attack on what at first appeared to be an insoluble problem. Incidentally these researches have yielded us precious information on the structure of all atoms and indeed it seems likely to have provided us with a key, so to speak, to unlock the secrets of the constitution of our material world.

Towards the close of the nineteenth century, when it seemed certain that the atoms of the elements were unchangeable by the forces then at our command, the discovery was made which has revolutionized our conception of the nature and relations of the elements. I refer to the discovery in 1896 of the radioactivity of the two heaviest elements uranium and thorium. It was soon made clear that this radioactivity is a sign that the atoms of

these elements are undergoing spontaneous transmutation. At any moment, a small fraction of the atoms concerned becomes unstable and breaks up with explosive violence, hurling out either a charged atom of helium, known as an $\alpha$-particle, or an electron called in this connection a $\beta$-particle. As a result of these explosions, a new radioactive element is formed and the process of transmutation once started continues through a number of stages. Each of the radioactive elements, formed in this way, breaks up according to a simple universal law but at very different rates. In a surprisingly short time, these successive transformations were disentangled and more than 30 new types of elements brought to light while the simple chemical relations between them were soon made clear.

We had thus been given a vision of a new and startling sub-atomic world where atoms break up spontaneously with an enormous release of energy, quite uninfluenced by the most powerful agencies at our disposal. Apart from uranium and thorium and the elements derived from them, only a few other elements showed even a feeble trace of radioactivity. The great majority of our ordinary elements appeared to be permanently stable under ordinary conditions on our earth. Science was then faced with the problem whether artificial methods could be found to transmute the atoms of the ordinary elements. Before this problem could be attacked with any hope of success, it was necessary to know more of the actual constitution of atoms. This information was provided by the rise of the nuclear theory of the atomic structure which I first suggested in 1911. The essential controlling feature of all atoms was found to reside in a very minute central nucleus which carried a positive charge and contained most of the mass of the atom. A relation of unexpected simplicity was found to connect the atoms of all the elements. The ordinary properties of an atom are defined by a whole number which represents the number of units of resultant positive charge carried by the nucleus. This varies from 1 for hydrogen to 92 for the heaviest element uranium and with few exceptions all the intervening numbers correspond to known elements.

On this view of atomic structure, it was evident that, to bring about the transmutation of an atom, it was necessary in some way to alter the charge or mass of the nucleus or both together. Since the nucleus of an atom must be held together by very powerful forces, this could only be effected by bringing a concentrated source of energy in some way to bear on the individual nucleus. The most energetic projectile available at that time was the $\alpha$-particle spontaneously ejected from radioactive substances. If a large number of $\alpha$-particles were fired at random at a sheet of matter, it was to be expected that one of them must occasionally approach very closely to the nucleus of any light atom in its path. In such a close encounter, the nucleus

must be violently disturbed, and possibly under favourable conditions the $\alpha$-particle might actually enter the nuclear structure, resulting in a transformation of the nucleus.

This mode of attack upon the nucleus at once proved successful. I found in 1919 that nitrogen could be transformed by bombardment with fast $\alpha$-particles. The process of transmutation is now clear. Occasionally an $\alpha$-particle actually enters the nitrogen nucleus and forms with it a new unstable nucleus which instantly breaks up with the emission of a fast proton (hydrogen nucleus) and the formation of a stable isotope of oxygen of mass 17. About a dozen of the light elements were found to be transformed in a similar way. The protons liberated in the nuclear explosions were at first counted by observing the flashes of light (scintillations) produced in phosphorescent zinc sulphide. This method was slow and very trying to the eyes of the observers. Progress however became more rapid and definite when electrical methods of counting individual fast particles were developed. These electrical counters, mainly depending on the use of electron-tubes for magnifying small currents, have now reached such a stage of perfection that we are able to count automatically individual fast particles like $\alpha$-particles and protons, even though they enter the detecting chamber at a rate as fast as ten thousand per minute. By other special devices, we are in like manner able to count individual $\beta$-particles. In this connection, I must also mention that wonderful instrument the Wilson Expansion Chamber which makes visible to us the actual tracks of flying fragments of atoms resulting from an atomic explosion. These remarkable devices have played an indispensable part in the rapid growth of knowledge during the last few years. It is to be emphasized that progress in scientific discovery is greatly influenced by the development of new technical methods and of new devices for measurement. With the growing complexity of science, the development of special techniques is of ever increasing importance for the advance of knowledge.

Up to the year 1932, experiments on transmutation were confined to the use of $\alpha$-particles for bombarding purposes. It became clear that the process of transformation was in most cases complex, since groups of protons with different but characteristic energies were observed when a single element was bombarded. This led to the conception that discrete energy levels existed within a nucleus and that under some conditions part of the excess energy was sometimes released in the form of a quantum of high frequency radiation.

The stage was now set for a great advance, and four new discoveries of outstanding importance were made in rapid succession in the period 1932-3. I refer to the discovery of the positive electron by Anderson in 1932, of the neutron by

Chadwick in 1932, of artificial radioactivity by M. and Mme. Curie-Joliot in 1933 and of the transmutation of the elements by purely artificial methods first shown by Cockcroft and Walton in 1932.

The discovery of the neutron—that uncharged particle of mass nearly 1—was the result of a close study of the effects produced in the light element beryllium when bombarded by $\alpha$-particles. It is noteworthy that the proton and the neutron, which are now believed to be the essential units with which all atomic nuclei are built up, owe their recognition to a study of the transmutation of matter by $\alpha$-particles.

Before the discovery of the neutron, it had been perforce assumed that nuclei must in some way be built up of massive protons and light negative electrons. Theories of nuclear structure became much more amenable to calculation when the nucleus is considered to be an aggregate of particles like the proton and neutron which have nearly the same mass. There was no longer any need to assume that either the positive or the negative electron has an independent existence in the nuclear structure. We are still uncertain of the exact relation, if any, between the neutron and the proton. The neutron appears to be slightly more massive than the proton but it is generally believed, although no definite proof is available, that the proton and neutron within a nucleus are mutually convertible under certain conditions. For example, the change of a proton into a neutron within the nucleus should lead to the appearance of a free positive electron, while conversely the change of a neutron into a proton gives rise to a free negative electron. In this way it appears possible to account for the observed fact that either positive or negative electrons are emitted by a large group of radioactive elements, to which I will now refer.

In the early experiments on transmutation by $\alpha$-particles, it was supposed that a stable nucleus was always formed after the emission of a fast proton. The investigations of M. and Mme. Curie-Joliot showed that in some cases elements were formed which, while apparently stable, ultimately broke up slowly, exactly like the natural radioactive bodies. Most of these radioactive bodies, formed by artificial methods, break up with the expulsion of fast negative electrons, but in a few cases positive electrons are emitted. Since the presence of these radioactive bodies can be easily detected, and their chemical properties readily determined, this new method of attack on the problem of transmutation has proved of great value. Nearly a hundred of these radioactive bodies are now known, produced in a great variety of ways. Some arise from the bombardment by fast $\alpha$-particles, others by bombardment with protons or deuterons. As Fermi and his colleagues have shown, neutrons and particularly slow neutrons are extraordinarily effective in the formation of such radioactive bodies. On account of its absence of

charge, the neutron enters freely into the nuclear structure of even the heaviest element, and in many cases causes its transmutation. For example, a number of these radioactive bodies are produced when the two heaviest elements uranium and thorium are bombarded by slow neutrons. In the case of uranium, as Hahn and Meitner have shown, the radioactive bodies so formed break up in a succession of stages like the natural radioactive bodies, and give rise to a number of transuranic elements of higher atomic number than uranium (92). These radioactive elements have the chemical properties to be expected from the higher homologues of rhenium, osmium and iridium of atomic numbers 93, 94 and 95 respectively.

These artificial radioactive bodies in general represent short-lived varieties of the isotopes of known elements. No doubt such transient radioactive elements are still produced by transmutation in the furnace of our sun where the thermal motions of the atoms must be very great. These radioactive elements would rapidly disappear as soon as the earth cooled down after separation from the sun. On this view, uranium and thorium are to be regarded as practically the sole survivors in our earth of a large group of radioactive elements owing to the fact that their time of transformation is long compared with the age of our planet.

It is of interest to note what an important part the $\alpha$-particle, which is itself a product of transformation of the natural radioactive bodies, has played in the growth of our knowledge of artificial transmutation. It is to be remembered too that our main source of neutrons for experimental purposes is provided by the bombardment of beryllium with $\alpha$-particles. The amount of radium available in our laboratories is, however, very limited, and it was early recognized that if our knowledge of transmutation was to be extended, it was necessary to have a copious supply of fast particles of all kinds for bombarding purposes. It is well known that enormous numbers of protons and deuterons, for example, can be easily produced by the passage of the electric discharge through hydrogen and deuterium (heavy hydrogen). To be effective for transmutation purposes, however, these charged particles must be given a high speed by accelerating them in a strong electric field. This has involved the use of apparatus on an engineering scale to provide voltages as high as one million volts or more and the use of fast pumps to maintain a good vacuum.

A large amount of difficult technical work has been necessary to produce such high direct voltages, and to find the best methods of applying them to the accelerating system. In Cambridge, these high voltages are produced by multiplying the voltage of a transformer by a system of condensers and rectifiers; in the U.S.A. by the use of a novel type of electrostatic generator, first developed by van der Graaf. Prof. E. O. Lawrence of the

University of California has devised an ingenious instrument called a 'cyclotron', in which the charged particles are automatically accelerated in multiple stages. This involves the use of huge electromagnets and very powerful electric oscillators. By this method, he has succeeded in producing streams of fast particles which have energies even higher than $\alpha$-particles ejected from radioactive substances. Undoubtedly this type of apparatus will prove of great importance in giving us a supply of much faster particles than we can hope to produce by the more direct methods.

It was at first thought that very high potentials of the order of several million volts would be required to obtain particles to study the transmutation of elements. Here, however, the development of the theory of wave-mechanics came to the aid of the experimenter, for Gamow showed that there was a small chance that comparatively slow bombarding particles might enter a nucleus. This theoretical conclusion has been completely verified by experiment. In the case of a light element like lithium, transformation effects can be readily observed with protons of energy as low as 20,000 volts. Of course, the possibility of transformation increases rapidly with rise of voltage.

The study of the transmutation of elements by using accelerated protons and deuterons as bombarding particles has given us a wealth of new information. The capture of the proton or deuteron by a nucleus leads in many cases to types of transmutation of unusual interest. For example, the bombardment of the isotope of lithium of mass 7 by protons leads to the formation of a beryllium nucleus of mass 8 with a great excess of energy. This immediately breaks up with two $\alpha$-particles shot out in nearly opposite directions. When boron of mass 11 is bombarded by protons, a carbon nucleus of mass 12 is formed which breaks up in most cases into three $\alpha$-particles. The deuteron is in some respects even more effective than the proton as a transmuting agent. When deuterons are used to bombard a compound of deuterium, previously unknown isotopes of hydrogen and of helium of mass 3 are formed, while fast protons and neutrons are liberated. The bombardment of beryllium by very fast deuterons gives rise to a plentiful supply of neutrons. Lawrence has shown that the bombardment of bismuth by very fast deuterons leads to the production of a radioactive bismuth isotope which is identical with the well-known natural radioactive product radium E. Many artificial radioactive elements can be produced often in great intensity. For example, the bombardment of common salt by fast deuterons gives rise to a radioactive isotope of sodium. This breaks up with a half period of 15 hours, emitting not only fast $\beta$-particles but $\gamma$-rays at least as penetrating as those from radium.

It may well be that in course of time such artificial radioactive elements may prove a useful substitute for radium in

therapeutic work. By these methods also, such intense sources of neutrons can be produced that special precautions have to be taken for the safety of the operators of the apparatus.

Sufficient I think has been said to illustrate the variety and interest of the transmutations produced by these bombardment methods. It should, however, be pointed out that transmutation in some cases can be effected by transferring energy to a nucleus by means of gamma rays of high quantum energy instead of by a material particle. For example, the deuteron can be broken up into its components, the proton and neutron, by the action of the gamma rays from radium or thorium. As a result of the bombardment of lithium by protons, gamma rays of extraordinarily high energy up to 17 million volts are strongly emitted. Bothe has recently shown that these high energy rays are able to transmute a number of atoms, neutrons usually being emitted in the process.

Some simple laws appear to hold in all individual transformations so far examined. Nuclear charge is always conserved, and where heavy particles are emitted, so also is energy when account is taken of the equivalence of mass and energy. Certain difficulties arise with regard to the conservation of energy in cases where light positive and negative electrons are emitted during transmutation, and there is still much discussion on this important question.

The study of the transmutation of matter has been extraordinarily fruitful in results of fundamental importance. In addition to the $\alpha$-particle, it has disclosed to us the existence of those two building units of nuclei, the proton and neutron. It has greatly widened our conception of the varieties of atomic nuclei which can exist in nature. Not only has it led to the discovery of about one hundred new radioactive elements, but also of several stable isotopes of known elements like $^{3}H$, $^{3}He$, $^{8}Be$ which had previously been unsuspected. It has greatly extended our knowledge of the ways in which nuclei can be built up and broken down, and has brought to our attention the extraordinary violence of some of the nuclear explosions which occur. The great majority of our elements have been transmuted by the bombardment method, and in the case of the light elements which have been most carefully studied, a great variety of modes of transmutation have been established.

Rapid progress has been made but much still remains to be done before we can hope to understand the detailed structure and stability of different forms of atomic nuclei and the origin of the elements. I cannot but reflect on the amazing contrast between my first experiment on the transmutation of nitrogen in the University of Manchester in 1919 and the large-scale experiments on transmutation which are now in progress in many parts of the world. In the one case, imagine an observer in a dark room with very simple apparatus painfully counting

with a microscope a few faint scintillations originating from the bombardment of nitrogen by a source of $\alpha$-particles. Contrast this with the large scale apparatus now in use for experiments on transmutation in Cambridge. A great hall contains massive and elaborate machinery, rising tier on tier, to give a steady potential of about two million volts. Nearby is the tall accelerating column with a power station on top, protected by great corona shields—reminding one of a photograph in the film of Wells's 'Things to Come'. The intense stream of accelerated particles falls on the target in the room below with thick walls to protect the workers from stray radiation. Here is a band of investigators using complicated electrical devices for counting automatically the multitude of fast particles arising from the transformation of the target element or photographing with an expansion chamber, automatically controlled, the actual tracks of particles from exploding atoms.

To examine the effect of still faster particles, a cyclotron is installed in another large room. The large electromagnet and accessories are surrounded with great water tanks containing boron in solution to protect the workers from the effect of neutrons released in the apparatus. A power station nearby is needed to provide current to excite the electromagnet and the powerful electric oscillators.

Such a comparison illustrates the remarkable changes in the scale of research that have taken place in certain branches of pure science within the last twenty years. Such a development is inevitable, for, as science progresses, important problems arise which can only be solved by the use of large powers and complicated apparatus, requiring the attention of a team of research workers. If rapid progress is to be made, such team work is likely to be a feature of the more elaborate researches in the future. Fortunately there is still plenty of scope for the individual research worker in many experiments of a simpler kind.

The science of Physics now covers such a vast field that it is impossible for any laboratory to provide up-to-date facilities for research in more than a few of its branches. There is a growing tendency in our research laboratories to-day to specialize in those particular branches of Physics in which they are most interested or specially equipped. Such a division of the field of research amongst a number of universities has certain advantages, provided that this subdivision is not carried too far. In general, the universities should be left free as far as possible to develop their own lines of research and encouraged to train young investigators, for it cannot be doubted that vigorous schools of research in pure science are vital to any nation if it wishes to develop effectively the application of science, whether to agriculture, industry or medicine. Since investigations in modern science are sometimes costly and often require the use

of expensive apparatus and large scale collaboration, it is obviously essential that adequate funds should be available to the universities to cover the cost of such researches.

In this brief survey, I have tried to outline the contributions to scientific knowledge made in India, and the needs of the immediate future if science is to play its part in the national welfare. While the study of modern science in India is comparatively recent, and naturally much influenced by Western ideas, it is well to recall that India in ancient days was the home of a flourishing indigenous science which in some respects was at the time in advance of the rest of the world.

The study of ancient writings has disclosed in recent years the extent and variety of these scientific contributions. Much progress was made in the study of arithmetic and geometry, while the researches of Sir Prafulla Ray have brought to light the important advances made in metallurgy and chemistry. May we not hope that this natural aptitude for experimental and abstract science, shown so long ago, is still characteristic of the Indian peoples, and that in the days to come India will again become a stronghold of science, not only as a form of intellectual activity but as a means of furthering the progress of her peoples.

# SECTION OF MATHEMATICS AND PHYSICS

*President* :—C. W. B. NORMAND, C.I.E., M.A., D.Sc., F.N.I.

# *Presidential Address*

## THE SOURCES OF ENERGY OF STORMS

During the year we have lost by death[1] one of our past Presidents, J. H. Field, and one of our most noteworthy. He was first of his year (1903) in Physics at Cambridge, had considerable mechanical ability and was a keen promoter of the cause of meteorology. He had vision and in addition had the character and personality to persuade a Government to many of his views. He originated the network of upper air and pilot balloon stations in India. We, who use the extensive data that have been collected during the past 25 years, may not often refer to Field by name, just because he was so thoroughly self-effacing amongst fellow scientists and wrote few papers himself, but we should not forget the debt we owe him.

The collection of data of the upper air has introduced a gradual revolution in the study and practice of meteorology in India, as it has done over the rest of the world. In my own experience the forecaster's methods have altered much. Whereas 25 years ago scanty data regarding cloud furnished almost the only indications of the ongoings within the ocean of air, to-day the forecaster has small auxiliary charts of streamlines for the levels of ½, 1, 2 km. and for a few higher levels up to 6 km, if low clouds do not intervene. The meteorologist as well as the aviator has reason to be grateful for these high-level charts which, along with the physical conceptions and methods of analysis introduced by the Norwegian school of meteorologists, are helping to lift the practice of forecasting out of its deep empirical ruts on to a plane where physical principles are directly applicable. The empirical stage was inevitable and has not yet ended; and the experienced empiricist could forecast very successfully on the whole; but I believe the forecaster of the newer type will, when he has had the same experience, be better still and certainly will have found weather forecasting to be a much more interesting exercise than it used to be. Contrast the man who is content simply to forecast 'rain' with one who tries,

[1] In the spoken address reference was also made to the deaths of Lord Rutherford and Sir J. C. Bose.

at the same time, to picture the process of the rain-formation. The latter sees the physical problem. Will the rain, he asks himself, be caused by the gradual upward glide of one air mass over another at a gentle angle, producing steady continuous rain; will it be the result of a convective break-through, of the shower or thunderstorm type; or will it be a gentle drizzle due to convergence and fall of pressure only? These are questions intimately associated with the sources of energy and the kinds of instability that occur in the atmosphere, questions to which I wish to devote special attention to-day.

The general theme of my remarks concerns the thermodynamical approach to the study of storms of all kinds, cyclones, thunderstorms, duststorms on the lines laid down by Margules during 1903 to 1906. At the basis of Margules' work and therefore of all that I have to say, there is the simple enough proposition, namely;—if the whole air mass around and including a storm can be circumscribed and considered as a closed system, it should be possible from a study of the initial and final conditions alone to decide the main source of the kinetic energy that has been created and displayed during the storm's existence. I am going to assume for the present that the energy does not come from the stratosphere,[1] which is beyond the scope of our daily weather charts and even beyond the ordinary reach of our instruments. Also we shall ignore for the present without discussion the possibility that there may occur a redistribution of kinetic energy alone without alteration of any other kind of energy, one central part of the system gaining in kinetic energy at the expense of the whole outer field. With these fundamental assumptions, we can, following Margules, simplify the discussion of sources of energy. The increase of kinetic energy in the storm's field must be explained by a transformation from some other forms of energy stored within the closed system. The other forms of energy are the gravitational and thermal (or internal). Margules previously in 1901 had considered the contribution from the potential energy of the pressure gradient only, which is really a fraction of the energy included under the thermal or internal energy. Can, he enquired, the kinetic energy of storms be a result of the pressure gradients alone? If all pressure differences over any area are suddenly abolished, will the energy thus set free be equivalent to the kinetic energy generally associated with a storm? His answer, if not his analysis, is clear enough, namely, this source of energy alone is quite insufficient. This answer nullifies a theory which had

[1] The sources of energy in the stratosphere have not yet been shown to be comparable in power with those of the troposphere. If the stratosphere has an important rôle in initiating tropospheric processes, it may act more as a trigger than as a source of energy. In any case, the more easily observable sources of energy within the troposphere itself are still awaiting full discussion based on adequate facts.

been put forward by another great Austrian meteorologist J. von Hann to explain the energy of tropical storms. Curiously enough, Hann brought his theory to notice again in *Nature* of 3rd March, 1921, but it does not, to my mind, bear critical examination. Now before either the gravitational or the internal energies can decrease within a closed system the stored-up energy must be present in a state of instability actual or potential. The possible diversities of instability, though numerous, are believed to be composites of three main kinds, which I shall call for brevity, the vertical, horizontal and latent types. The vertical and horizontal types refer to the behaviour of dry air, or at least air which is dry enough to remain unsaturated during the changes considered.[1] The latent instability is that which arises from the latent heat of water vapour.

### INSTABILITY FROM VERTICAL DECREASE OF ENTROPY

The limit for stability is reached when the vertical gradient of temperature (or the lapse-rate, as it is ordinarily referred to in meteorology) becomes that of convective equilibrium, in which the air temperature decreases upwards about 9·8°C. every kilometre. The air has then the same entropy everywhere and no work is done in transferring a unit of it to any other level. Wherever the air unit is moved, it automatically changes pressure and temperature to agree with its surroundings. When this limit is passed, instability sets in. Now liquids in a jar or strata in the ocean set themselves according to density, but the layers in the atmosphere always tend to take up positions according to their entropies—those of greatest entropy uppermost. Usually, indeed, the entropy of dry air does increase upwards. The average lapse-rate is not 9·8°C. but only about 6°C. per kilometre. The best picture of the normal atmosphere is that stressed by Sir Napier Shaw of stratified layers, each resilient and to a certain degree obstinate and resistant towards any attempt towards upwards or downward motion of other masses of air through it. We see evidence of this normal feature in the tendency of many clouds to form in layers. The degree of stratification varies and sometimes is pierced or broken down altogether, usually, as we shall see, by the latent heat of water vapour, but sometimes over shallow depths by the lapse-rate exceeding that of convective equilibrium—by this vertical type of instability, as we have called it. The sun's heat on the ground is a potent agent in creating vertical instability. It makes the surface layer unstable over tropical land every sunny day. There's a tendency for this type of instability to develop, too,

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[1] This condition is introduced here for simplicity of discussion. In actual examples air may become saturated, but if originally it has no convective instability there is no additional instability produced as a result of the condensation within the closed system.

whenever the upper layers come from a colder source than the lower layers. Yet, despite its significance as a weakener of resistance or, as we shall see later, as a kind of trigger, it is not of prime importance in the study of a storm's energy, because, behind it, there is no means of storing up energy. The only checks to the immediate development of a vertical circulation, when the lapse-rate passes beyond the dry adiabatic, are the viscous forces, which in the main body of the atmosphere may impede the vertical circulation a little but never help to build up any important reservoir of energy.

### Instability from horizontal change of temperature.

This second type of instability is exemplified by a warm and a cold current of air moving parallel to each other. We are all accustomed nowadays to the notion of the meeting of air masses from different parts of the earth, of polar air encountering tropical air, or monsoon air coming into proximity with continental air. Ordinarily, one might expect two such currents when brought alongside one another to react immediately. On a rotating earth however (as Helmholtz and Margules first proved for us) an equilibrium position can be set up. Any mass that moves on the earth experiences, on account of the earth's rotation, a force tending to push it to the right. So, if a warm air current is moving relatively past a cold current of air on its right, it exerts a pressure by virtue of its motion, which tends to counteract the extra pressure or weight of the cold air. In the position of equilibrium the surface of discontinuity has a slope that depends upon the relative motion of the two currents, the latitude and the difference in temperature. The important aspect of this from the point of view of the present discussion is that here is a means of storing up energy. So long as the surface of discontinuity is in equilibrium, a large difference of temperature may be maintained in adjacent air masses. When the position of equilibrium is broken down by any agency, perhaps by a pronounced pressure wave, there is obviously a considerable store of potential energy readily available for transformation into the kinetic form of wind and gale, the cold air breaking through with all the display of a 'line squall' or 'cold front'. The Norwegian school of meteorologists, under B. Bjerknes, regard the cyclone of temperate latitudes as a wave on a surface of discontinuity, the wave partly modifying by its own energy the kinetic energy already present in the currents and partly utilizing the potential energy of position to overcome the viscous forces and to nourish any development that may occur.

### Instability due to Water Vapour.

(*a*) *Convective Instability and Wet-bulb Temperature.*—The third main type of instability arises from the latent heat of water

vapour and is dependent upon the power of vapour in the atmosphere to act as a reservoir of energy. Just as there is a limit to the lapse-rate of temperature for dry air, so there is a limit to the lapse-rate of wet bulb temperature, which on being exceeded is a potential source of energy. This type of instability has been named ' Convective Instability ' by Rossby, because a layer with this property will, if lifted adiabatically and bodily, become saturated and then be in an unstable state, analogous to the superadiabatic condition for dry air. Kinetic energy is set free in the stabilizing process, which ensues when each unit of saturated air seeks to reach its proper entropy level. I defined convective instability with reference to the lapse-rate of wet bulb temperature, because in all adiabatic movements in the atmosphere the wet bulb temperatures have an importance of their own, and especially so, in those processes in which evaporation or condensation occurs. The (ventilated) wet bulb temperature is an interesting physical entity, worthy of a little more attention than it ordinarily receives in text-books of physics, where it is treated as a mere stepping stone towards the determination of relative humidity. The wet bulb temperature has other practical aspects. When the householder in northern India keeps his rooms cool in the hot weather by placing wet grass screens on the doors that face windward, he reduces the dry bulb temperature greatly but, though he may not always realize it, he leaves the wet bulb unaltered. The value of the wet bulb temperature lies in it being a measure (though non-linear) of the heat content of a mixture of air and water-vapour, taking latent heat into account. For example, the engineer, when faced with problems of air-conditioning knows that no purely evaporative method can cool air at the ordinary temperature to any point lower than the wet-bulb temperature. If he has to aim at a lower air temperature than the wet bulb, he must adopt a different method, instal a refrigeration plant or have a plentiful supply of really cold water to aid him. The processes taking place at a wet bulb are adiabatic, though irreversible and therefore not quite isentropic.

The criterion for ' convective instability ', which we shall consider graphically later on, is of a very general nature. It takes account of the wet bulb temperature, but none of the associated relative humidity or of the general stability of the air column. The whole air mass may in fact be so stable that the potential energy of the layer of convective instability may never be realized at all or, if it is, may be very small in comparison with the amount of work needed to raise the layer to the point of realization. Throughout our dry weather season in Poona, a time of settled weather, the association of ' convective ' instability with general stability is a common feature, showing that convective instability has no necessary association with disturbed weather, and that, to arrive at a more practical criterion, the

definition of the instability due to water vapour must be narrowed down.

One interesting feature however of convective instability is its relationship with the problem of vertical convection or eddy-conduction of heat or entropy. When convective instability exists, we know that the entropy of the mixture, air plus water-vapour, decreases upward and that turbulence must then tend to carry entropy upwards. If the presence of water vapour is ignored, one may be tempted to deduce that turbulence works almost completely towards carrying entropy downwards, because the lapse-rate is less than the adiabatic. Taking account however of the latent heat and noting that convective instability is practically always present in the lower layers of equatorial air throughout the year and in temperate latitudes in the summer months, and that turbulence is greatest in the day-time when the lapse-rate of temperature is greatest, we see that the carriage of entropy from the ground upwards by turbulence may be a more important process than it was at one time believed to be.

(*b*) *Latent Instability.*—Refsdal in Norway was the first to explain clearly certain essential conditions for the storage of energy by water vapour and introduced the phrase 'feucht-labil' to describe the associated type of instability. Almost simultaneously a slightly different approach was made in India to this problem. A kind of metastable condition was recognized and defined as 'latent instability'.

The importance of the latter will become more obvious when we go on to consider a thermodynamically closed system. The essential point is this:—let the metastable or 'latent' state be disturbed by a trigger, then the ensuing release of energy is large compared with that supplied by the trigger. It is an interesting type of instability because it can develop behind a veneer of stability. It is of the same type as a vertically expanding pencil standing on end, or analogous to a hydrogen balloon caught in the corridor of a large hall where it can be fed with more and more hydrogen, but cannot escape up to the dome until given a small push. A balloon in this state is stable for small but unstable for large displacements. So also a quantum of air in the atmosphere, that is in the state of 'latent' instability due to water vapour, will respond to large but not to small displacements. The instability may develop in various ways, for example, in an otherwise homogeneous air mass, if the lower layers of the air pass over a sea, which is considerably warmer than the wet bulb temperature of the air; or if the air passes over warm moist soil. Alternatively, convective or latent instability may arise in a column of air, of which the upper and lower layers have different origins, the lower layer coming from a warm moist source. In Bengal one may recognize this condition in the winds of the hot weather and the nor'wester months, when the lower winds are from the Bay of Bengal and the upper

winds from northern India. In general, an oceanic current in the lower layers appears to be essential for the development of latent instability in India.

The atmosphere has various means of releasing the energy of latent instability. Over the land the most common trigger is the heating up of the surface layers in the day-time, creating instability of the vertical type. We see the result in the dust-storms and thunderstorms of the afternoon and evening hours. Another trigger is convergence of air, which acts on the air layers like the lateral squeezing of a rubber sponge causing vertical extension and therefore altering the lapse-rate in a fashion favourable for release of energy. A third type of trigger is horizontal instability, i.e. the presence of another air mass in the neighbourhood, which may be shallow and yet by undercutting the warmer moist air may raise it just sufficiently to overcome the initial resistance.

MARGULES; AND QUANTITATIVE ESTIMATES OF AVAILABLE ENERGY.

These are the main types of instability and we wish to have a means of estimating quantitatively their relative importance in originating storms. Margules' thirty-year-old discussion of this point, particularly on the vertical and horizontal types of instability, is full and illuminating.

Regarding the energy available from latent heat of condensation, Margules' method of approach was interesting but not sufficiently complete. At one time he concluded from his quantitative studies that the latent heat of condensation had little influence on the development of a storm and contributed little or nothing to the sum total of its kinetic energy. In his final[1] contribution to Meteorology (1906) he conceded some importance to the heat of condensation in tropical storms, but not in those of temperate latitudes, and even in the tropical storms he thought that the potential energy dependent upon the horizontal distribution of temperature would prove to be of chief importance, only a part of the latent heat of condensation being transformed into kinetic energy and therefore playing a subsidiary rôle.

Margules' analysis and methods remain the standard to this day. His papers perhaps have not been studied by meteorologists as closely as they deserve to be; they are not easy to read and the full implications of his analysis are not easy to grasp. Although he offered approximate simple solutions for some cases, his main applications to particular cases involved arduous computations; pressures at various heights as well as all the subsequent computations were calculated with a high

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[1] He lived until 1920, but unfortunately wrote no more on meteorological subjects.

degree of accuracy, because the final result depends upon the small difference between two large quantities, e.g. between 233·5132 and 233·4140, as in one of his now classical, oft-quoted examples. The present is an appropriate occasion to recall some of his examples, because we have seen recently how graphical methods may be borrowed to clarify and extend Margules' work, have understood more clearly the conditions under which latent heat may be of great importance in storm development and my colleagues are using these ideas in certain investigations in Indian meteorology, in which the general aim has been to begin once more from fundamental principles with the aid of upper air observations, and to see if by a comparative study of the initial and final 3-dimensional fields of temperature and humidity it is possible to conclude which type of instability, vertical, horizontal or latent, is mainly operative in various typical situations. If a decision can be reached, it will guide further investigations and ease the study of the dynamical aspects.

The quantitative discussion that follows of some very simple types may lead one to think that they are too simplified to cover the complex processes of the atmosphere and understate the possibilities to such an extent that the final conclusion, whatever it may be, will have little application in nature. The meteorologist knows the danger of this full well, but the human mind cannot advance a subject without making abstractions; and these particular abstractions are useful and believed to be adequate. After all, unless we have some clear fundamental ideas to build upon, it is difficult to discern whether different workers are discussing matters at cross purposes, or in their discussion of complex situations how far they are on common ground.

In order to express Margules' main results graphically, it is necessary to include the use of a type of diagram, adapted for meteorological computations, in which area is proportional to energy. It may be a $p$–$v$ diagram, or $T$–log $p$, or log $T$–$T$ log $p$, or a temperature-entropy diagram.

*The temperature-entropy diagram or tephigram.*—I choose the temperature-entropy diagram, for the meteorological form

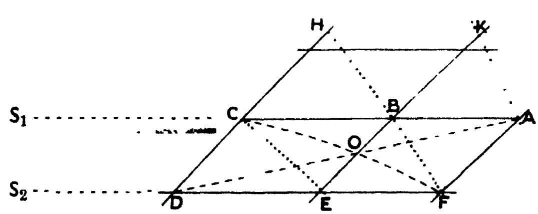



FIG. 1.

of which we are indebted, along with so many other ideas, to Sir Napier Shaw. Meteorologists are familiar enough with this form of the temperature-entropy diagram, briefly called the tephigram; as others may not be, I must introduce a brief description of it here. The ordinate is entropy of dry air, increasing upwards, and the abscissa temperature increasing to the right. Isothermals are vertical lines. Isentropics like *AC* and *FD* of fig. 1 are horizontal. Now entropy is a function of pressure and temperature. So, isobars are also entered on the diagram. They are almost straight diagonal lines (e.g. *AF*, *KE*, *HD* of fig. 1) representing values of pressure that decrease towards the top left hand corner. The pressure and temperature of a unit of air being known, it can be represented by a point at the intersection of the appropriate isobar and isothermal. The entropy can then be read off, if required.

Before going on to the discussion of stability, let me show a less sketchy form of the tephigram in a guise, in which it is used for much aerological work, particularly for entering aeroplane ascents. To illustrate the extent of the diagram and how and where observations appear on it I have entered strips, representing the normal variation of the mean daily temperature of Calcutta, Darjiling, top of Mt. Everest (conjectural, of course), London, Sonnblick at 3000 m. in the Alps and some temperatures taken near the bottom level of a mine in the Kolar Gold Fields (Mysore), when the ventilation was good. I enter the observations of the bottom of a deep mine, as a reminder to ventilation engineers that charts like these offer an alternative method of approach to ventilation problems and allow the actual dry and wet bulb temperatures down a shaft to be compared with those theoretically obtainable when air is driven down the shaft adiabatically.

This diagram also contains curved lines, almost at right angles to the isobars. These indicate how the effect of the latent heat of condensation is allowed for on a temperature-entropy diagram. It is an adaptation of the graphical method introduced by H. Hertz 53 years ago. Ascending saturated air forms cloud and so gets a contribution from latent heat to lessen its lapse-rate. Accordingly, the fall of temperature from isobar to isobar is less on the saturated adiabat than on the dry. The isentropies of a saturated mixture therefore appear as these curved lines (*cf. AK*, *FH*, *EC* of fig. 1). We may label them as the family of $\acute{S}$-curves and remember that they are related to the entropy of moist air, i.e. the entropy of a mixture of air and vapour, of which the latent heat is taken into account. Now, when air is saturated, the wet and dry bulb temperatures are identical. Hence an $\acute{S}$-curve traces the course of the wet, as well as of the dry, bulb temperatures of saturated air in adiabatic movements. To a certain degree of approximation, sufficient for practical purposes, they trace also the course

of the wet bulb temperatures in all adiabatic movements, even when the air is not saturated. Another function can be defined that has an exact relationship with the $\acute{S}$-curves, but we make use, in what follows, of the approximate correspondence with wet bulb temperatures, because the latter are familiar to us all, and ordinarily available in meteorological practice. For the discussion of questions of stability, when condensation or evaporation is part of the processes at work, the wet bulb temperatures as well as the dry are entered against the appropriate pressures on the temperature-entropy diagram. Here, for instance, is how soundings representative of average conditions in January and July at Agra appear on tephigram paper, both dry and wet bulb curves.

One more point concerning these $\acute{S}$-curves. Each can be given a number corresponding to the point where they cut the standard pressure. This value represents the wet bulb temperature of the unit of air, if reduced to standard pressure and so is called the 'wet bulb potential temperature',—a most useful function in meteorology, because it is an invariant in all adiabatic processes, even if evaporation or condensation occurs.

*Energy from vertical instability (discontinuous change).*—Mathematically the simplest case of vertical instability to consider is one in which an air mass of entropy $S_2$ is superposed above another of entropy $S_1$ where $S_1$ is greater than $S_2$, the whole forming a closed system with a frictionless piston of constant weight on top. The maximum release of energy is achieved when the process is adiabatic and the two layers do not mix but readjust themselves to the equilibrium position as if each remained in its own perfectly flexible, frictionless, weightless envelope, as if indeed the movement resembles that of the overturn of a water-oil system, in which water is originally on top of the oil and finishes below. The change is illustrated in fig. 2.[1] position (*a*) changing to position (*c*). The energy, that

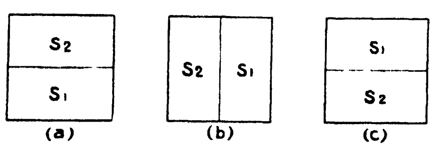



FIG. 2.

is released during the change, arises from the fall of the centre of gravity of the system and from a certain decrease in the internal energy. What does that energy amount to ?

[1] These graphical methods can be extended to examples in which the air columns in fig. 2, *a* and *b*, are not isentropic, but I have not the time to develop these points here.

On the tephigram a solution can be given that is both simple and valid to a high degree of approximation. The system is represented by (*cf.* fig. 1)—

(*a*) initial condition : $AB$, representing column $S_1$,
and $ED$, representing column $S_2$.

The air temperature of the whole column is represented by $ABED$. When this overturns adiabatically, the air in $S_1$ retains its entropy, so that $AB$ moves up to $BC$. Similarly the layer $ED$ moves down along the isentropic to $FE$. Hence—

(*b*) final condition : $FE$, representing column $S_2$,
and $BC$, representing column $S_1$.

Now the tephigram is ordinarily intended to indicate the work done by or on a unit mass of the working substance. The lines $AB$ and $ED$ in this instance give us the environment within which the particles give up or receive their energy. It is easy to see that the first upward moving unit and the first downward moving unit each gain energy corresponding to one half the area $ACDF$. Other particles gain less energy. To integrate the energy for the whole mass, we may imagine an ordinate perpendicular to the paper (in fig. 1) representing mass. The total energy is given approximately by the volume of a wedge on the base $ACDF$, with edge uppermost and at a height of $M/2$, if $M$ is the total mass. Hence the total energy is $(M/4) \times$ (area $ACDF$), and the average energy per unit mass, obtained by dividing the total by $M$, is $\frac{1}{4}$th the area $ACDF$. When the height of each column is 2000 m. and the difference between them at the discontinuity is 3°C. the average kinetic energy computed from the tephigram is 14·7 m.p.s. (or 33 miles an hour) compared with 14·85 m.p.s. computed more laboriously by Margules.

It is quite obvious that all units will not gather the same amount of kinetic energy,—some will have more, others less—and that a proportion will be dissipated during the movement by eddy viscosity, which in turn introduces irreversible and inefficient changes, decreasing the available energy. The 14·7 m.p.s. represents a *maximum value* for the *average* velocity that can be produced by the change. So also in all the following examples, only the *maximum* possible value of the average velocity will be mentioned ; and all the processes of mixing and turbulence that lead to gain of entropy and loss of available energy are consciously neglected here.

This type of vertical instability, with discontinuous change from lower to upper layer, is mainly of theoretical interest. It has its chief value in leading on to the ready calculation of energy from other types of instability.

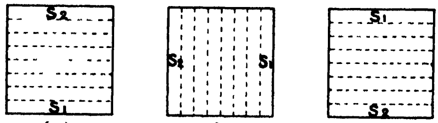
*Energy from Vertical Instability* (*continuous linear change*).— is type of vertical instability that is more frequently encountered A that with continuous change of lapse-rate. For example, under strong sunshine a superadiabatic lapse-rate is generated

near the surface of the ground. Entropy decreases upwards and therefore the condition is represented on a tephigram by a curve sloping like *AD* (fig. 1). The ideal stabilizing of this condition is attained by each layer seeking its proper entropy level, i.e. by unit particle from *A* moving adiabatically to *C*, unit particle from *D* to *F*, and in fact the lapse-rate *AD* changing to *CF*. Integrating the realizable energy in the same manner as before, we find the total energy to be equivalent to the volume of a pyramid of height $M/2$ upon the base *ACDF*, or $(M/6) \times$ area *ACDF*. Dividing this total energy by $M$ we get the average energy per unit mass to be equivalent to 1/6th the area *ACDF*. As a numerical example, consider a layer of depth of a kilometre with a vertical lapse-rate of 12°C., which is 1·23 times the convectively neutral rate; the tephigram tells us that the overturning of the layer can give rise to wind averaging 10 miles an hour. Instability of this type is known to give rise to turbulence and small convection columns.

*Energy from Horizontal Instability (discontinuous change).*—Suppose that a vessel, with a vertical partition, contains two equal air masses, side by side, each of constant entropy, the values of entropy being $S_1$ and $S_2$ respectively, where $S_1 > S_2$; again, there is a frictionless piston of constant weight on top. When the partition is removed, the mass $S_1$ flows on top of the mass $S_2$ with release of energy which can be computed graphically as before. But the approximate solution can be seen more readily and immediately by glancing again at fig. 2. Our first example of vertical instability was of the type (*a*). The present example of horizontal instability is (*b*). Both lead (ideally) to the final position (*c*). Now (*b*) is obviously a half-way house in the change from (*a*) to (*c*). So, if the change from (*a*) to (*c*) could release, at the maximum, a kinetic energy per unit mass equivalent to a certain area on the tephigram, then the change from (*b*) to (*c*) will release energy equivalent to one half of that area. To go back to fig. 1, if *AC* and *FD* represent on a tephigram the two air masses lying side by side, the average kinetic energy released when the system passes over to the stable state is 1/8th the area *ACDF*. Expressed in numerical values the velocity that may be generated from two air masses 3 km. high and with 10°C. difference in temperature averages 17·3 m.p.s., while masses 6 km. high with same temperature difference get average velocity of 25·8 m.p.s.

*Energy of Horizontal Instability (continuous linear change).*—The partition between a hot and a cold air mass, lying alongside one another, may not be and usually is not discontinuous. If the change of potential temperature from the one to the other is continuous and linear, it is again possible to see what the approximate solution must be, when entropy varies horizontally only and not vertically. Let us look at fig. 3. We want to know the energy released in passing from position (*b*) to position

(*c*). Now (*b*) is obviously the approximate half-way stage between the vertically unstable position, of superadiabatic




(a) (b) (c)

FIG. 3.

lapse-rate, (*a*) and the stable position (*c*). We have seen how to calculate the kinetic energy arising from the change from (*a*) to (*c*). The change from (*b*) to (*c*) must be half that amount. For example, if in fig. 1 the column of air at one end of the continuously changing zone is initially represented by *AC* and at the other end by *DF*, the average change in kinetic energy can amount, at most, to the equivalent of $\frac{1}{2} \times \frac{1}{6} \times$ the area *ACDF* by the time the final stable position is reached. Incidentally this result shows up clearly the limitations of the method. The available energy depends only on the two end values of entropy $S_1$ and $S_2$ (fig. 3 *b*), and not on the distance apart of $S_1$ and $S_2$. But the actual velocities immediately generated will in fact be very different when $S_1$ and $S_2$ are poles apart and when $S_1$ and $S_2$ are near together—within a closed system that covers only a few degrees of latitude. In the former, the time factor is overwhelming and turbulence and eddy motion totally prevent any approximation to the velocities calculated in this fashion.

## Energy from latent instability.

On the tephigram 'convective instability' is recognized immediately in any layer from the slope of the wet bulb curve being less steep than a saturated adiabatic or $\acute{S}$-curve. How such a layer responds to adiabatic lifting in the atmosphere is illustrated on a tephigram. To recognize 'latent instability' one must examine the dry bulb curve also; both dry and wet bulb curves must be less steep than, and be cut by, one and the same $\acute{S}$-curve. For real latent instability the amount of work to be done to a unit particle in order to raise it up first of all to condensation level and beyond to the equilibrium point must be less than the energy gained by it in the succeeding buoyant stage (as illustrated).

To gauge the possible importance of latent instability let us try to estimate, by a brief study of a somewhat extreme example, how much kinetic energy can, at the maximum, be produced by latent instability alone, unassociated with other types of instability. I am going to assume, as our closed

system, a column of air with a dry bulb temperature of 100°F at ground level, an adiabatic lapse-rate of temperature up to 8 km. and a large inversion of temperature at that level. The assumption of an adiabatic lapse-rate through so great a depth of atmosphere is an exaggeration that is countered to some extent by the amount of the assumed inversion. In fig. 4, the air temperature is represented by the line *AF* and the inversion by *FE*. Now it is a matter of observation that different air masses with different past histories may have the same air temperatures but different humidities. We can picture one such air mass (e.g. in fig. 4, *AF* and *JF* being the dry and wet bulb curves) with insufficient humidity and without latent

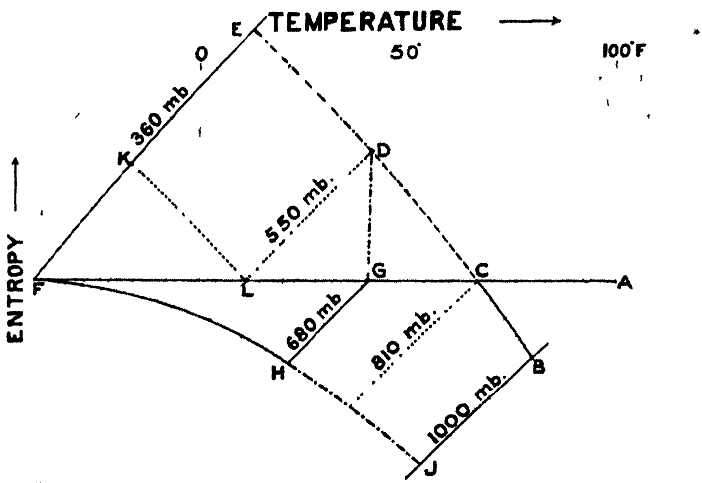



Fig. 4.

instability, in which there is no release of mechanical energy on rearrangement of the air column. Another air mass with the same air temperature may be pictured to have a large amount of latent instability, i.e. with much higher wet bulb temperature in the lower layers (e.g. in fig. 4 *BCGHF*, instead of *JF* may be the wet bulb curve). If the lower half of the mass of air ascends, much cloud and rain is produced, and the rearrangement is accompanied by a great release of kinetic energy. If we imagine the descending air to be unaffected by the falling rain, the maximum energy that may be generated is represented by the volume of a simple solid figure on the base *CEF* (model shown), which when averaged over the whole mass is equivalent to

a hurricane of 80 miles an hour, the final state being represented on the tephigram by dry bulb curve $EDGA$, wet bulb curve $EDGHJ$. It is a remarkable fact that a change in the lower half of the wet bulb curve alone without any other change at all has raised the theoretically possible wind from zero up to hurricane force. Enormous though that change is, it does not express all the theoretical possibilities of 'latent instability'. In the above calculation the descending air maintains its original water content. Suppose however that, in a manner apparently analogous to, yet in principle different from, the demon of Clerk Maxwell, the spirits or sylphs of the air were clever enough to arrange for each descending unit to take full advantage of the falling rain. Each sylph would be under orders to make the most of but not to transcend the laws of thermodynamics. Each sees its unit of air saturated and cooled to the wet bulb temperature *in situ* before allowing it to begin to fall and then takes care to keep it saturated by rain throughout the descent. Under these conditions the descent takes place along an $\acute{S}$-curve not along a dry isentropic and the coldness and density of each unit, relative to its environment during descent provide another great source of energy. The final condition is represented by ;—

dry bulb curve—$EDGHJ$. wet bulb curve—$EDGHJ$.

Making a simple calculation on the tephigram (model exhibited)[1] we see that descending saturated air can (in theory) contribute as much to the available energy in this case as the ascending air. That is, the over-turn of the air in the closed system can, if the process is conducted with maximum thermodynamic efficiency, give rise to a wind averaging 115 miles an hour throughout the air column.

The above is an imaginary example and an extreme case. A more practical case may perhaps be illustrated by entering on a tephigram the typical monsoon curves of dry and wet bulb up to 3 km. (using July averages for Poona) and curves of continental air at higher levels (using April averages for Agra). The available energy from this combination suffices to provide an average velocity of 50 miles an hour distributed throughout the whole system, if evaporation from rain is not taken into account, and over 60 miles an hour, if it is. In practice, of course, turbulence, the mixing of air at different temperatures, and other irreversible changes intervene. Even so, it is obvious that we are dealing here with a source of energy in the atmosphere that may suffice to produce as much kinetic energy as is displayed in storms. This source of energy is particularly prevalent in the tropics, where latent heat is more of a reservoir of energy than in temperate latitudes, because of the increase of vapour pressure

[1] The total energy from descending air is represented by an irregular wedge-shaped figure on the base $AFJ$, the top of the wedge being vertically above $GH$.

with temperature. It may be said that this is a very old idea. I agree, but it is one on which we have new light. I think I am right in saying that the fluctuating history of the condensation theory of storms, sometimes in fashion and sometimes out, has been partly due to two facts, first that the exact conditions of storage of latent heat as potentially available energy were not clearly realized before the present decade and secondly because no adequate estimates of the energy realizable within a closed system through the agency of this type of instability alone have, until quite recently, been available.

### THUNDERSTORMS AND DUSTSTORMS.

The point that we have just examined regarding the possible release of energy from descending air is of special interest, when we pass on to the application of these quantitative methods to examples of duststorms and thunderstorms. The general tendency in meteorological practice to neglect consideration of the descending air is easily understood, because cloud and rain force special attention upon the ascending air. When however the quantitative examination of energy is attempted, we must treat the thunderstorm or duststorm and its surroundings as a closed system. We must picture to ourselves what happens to the descending air and cannot remain content with the conventional diagram of the 'heat' thunderstorm in which the lowest layers of one kilometre in depth nourish the thunderstorm cloud up to a height of 9 kilometres. As the cloud advances its great capacity continues apparently to be fed from the lowermost layers, but no sufficient compensating down-current is shown. The conventional picture does not show what happens to the great column of air from 1 to 9 kilometres which is displaced by the cloudy air. The downward current that is depicted just behind the roll or squall cloud in the conventional diagram has an origin that is always apparently in the lower portion of the cloud and in essence therefore signifies a return to earth of the air that was originally there. There is a serious difficulty in this. If an original state of instability caused the surface air to rise, it is reasonable to suppose that most of it will tend to remain aloft having moved of its own accord to a level where it will find stability. Also air that travels the cycle up through the cloud and down again to earth should arrive at ground level with its wet bulb temperature unchanged if the cycle is adiabatic, and, in any case, with very little change in wet bulb if the cycle is rapid (as it is in a thunderstorm). Hence the low wet bulb temperatures are not explained by any vortex-like return to earth of surface air, even if it is rain-drenched in the process. Normally, in meteorological theory one is chary of allowing air to descend,

unless it is pushed down under the agency of an outside force or at the expense of some available supply of energy. Now quite strong evidence, though not yet complete and overwhelming, has been collected in India recently to show that latent instability is a normal percursor of all 'heat' thunderstorms and duststorms. The tephigram tells us that efficient use of the instability requires an active, self-accelerating downward current, not merely a passive descent. The downward current is one of the most noticeable features in severe thunderstorms and duststorms, bringing with it the strong squally wind of great dust-raising power and sudden drop of temperature just before the rain begins. From what height does that downward current come? We don't know yet. But all this suggests a somewhat different picture for the ideal, efficient self-propagating thunderstorm, one in which rain-drenched descending winds play their part, as would streams of water of varying temperature debouching from a multi-channelled circuit, the hottest stream from the lowest channel and the coolest on top. We can picture continuity in the stream flow, although the topmost layer finishes below. It may be, of course, that many of the convective storms in nature have no great thermodynamic efficiency. We need much more information with regard to that point from balloon observations. The descending movements certainly need more investigation. The simplest theory to work to, in the absence of further knowledge, is to imagine that low wet bulb temperatures after a storm are carried down by air that descends without change of wet bulb potential temperature (i.e. the wet bulb temperature descends along an $\acute{S}$-curve). The comparatively few observations that are available give heights of anything up to 4 or more kilometres for the level from which air may have descended during thunderstorms. In this way it is possible to explain certain low wet bulb temperatures after storms that cannot be explained by any horizontal advection of air.

If a local heat thunderstorm can develop its own downward current, it can create its own cold wave which acts as the trigger to continue the action in the direction towards which the storm is moving. This type of cold wave is different in origin from that arising from the state of 'horizontal instability' discussed above. It comes from the upper air and is a direct consequence of the initial latent instability.

Several workers in India have been studying the problems of dust- and thunder-storms in recent years, but always one feels the lack of the right observations. We want the observations from a number of places in and around a storm field before, during and after the storm. Unfortunately we cannot control the storm as a physicist controls a laboratory experiment and the *bundobast* needed to get all the necessary special observations is expensive. We have not been able yet to achieve our desire, but even the clearer perception of an objective is a gain.

## CYCLONES.

In this city where the word 'cyclone' was first invented and used by Henry Piddington 90 years ago, it is scarcely fitting to close this address without a more specific, even if it must be a brief, mention of tropical cyclonic storms. Piddington, after a training in the Mercantile Marine, became Curator of a Museum in Calcutta and Secretary of the Asiatic Society of Bengal. He seems to have used the word 'cyclone' first of all in his seventeenth memoir on storms, which was published, as all his memoirs were, in the Journal of the Asiatic Society of Bengal. There's a stroke of genius in the suggestiveness of the word 'cyclone'; while his book for mariners about the laws of storms was of great practical value to seamen of all nations. Since Piddington's day many able men have studied the cyclones of the Bay of Bengal, notably H. F. Blanford and J. Eliot, but the essential requirements, or, as the mathematician would say, the necessary and sufficient conditions for the formation of a cyclone still elude us.

The forecaster builds up his impressions from his day-to-day experience. For the development of most, at least, of the major cyclones he is convinced of the importance of the presence of two or more distinct air masses over the Bay. Further, he expects the storm, if it does form, to develop on the zone of partition between two air masses. The partition may not, generally does not, show any sharp discontinuity and may only be a zone of gradual change. Another undoubted item of importance in cyclones is the water vapour, exhibited by the rainfall and by the rapid decay of the storm whenever the rich source of vapour is cut off. The first item suggests horizontal and the latter latent instability as important sources in cyclones, which in a sense takes us no further forward than a century ago, when such theories were first put forward. We may have formed our own opinions but have not yet proved conclusively which is the more important type of instability; we don't know yet whether sufficient latent instability can develop within a single homogeneous air mass to nourish, say, a cyclonic storm of the monsoon type or a cyclone that is transmitted as a depression in the upper air from the China Seas to Indian waters and there re-develops. The final verdict may be towards some reconciliation of the two old opposing theories of condensation and juxtaposition, on the lines that the zone of partition between two air masses is, in favourable conditions, the seat of most intense latent instability [*cf.* the example already cited on p. 15 of latent instability formed by monsoon air below continental air]. Undoubtedly, the energy is sometimes there in great quantities, on and near a partition zone, ready to take part in cyclonic development, if it can be organized. The latter is the side of the problem that the methods of thermodynamics

do not touch. How is the release of energy organized into the cyclonic form out of the other form of release, namely, that of local thunderstorms and frequent heavy rainsqualls? The answer to this question will require the application of hydrodynamical as well as thermodynamical methods. To explain European cyclones, the Norwegian meteorologists in recent years have sketched a theory of unstable waves of great wavelength of the order of 1000 km. developing under the forces of gravity and of earth's rotation on a frontal surface separating air masses of different densities. When however latent instability is the main source of energy, the differences of density are less and the same theory may not apply at all or may require to be greatly modified.

To settle the thermodynamical question, we need to be able to measure the humidity of the upper air as accurately as the temperature and then we have to gather upper air observations of temperature and humidity from the shores of the Bay of Bengal, if not from the sea area itself, before, during and after cyclones. Collecting adequate data costs money and at present we must go slowly, but we are ever hopeful that in time we shall have the data and find the solution. The Bay of Bengal, with its cyclones, is ever our challenge.

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# SECTION OF CHEMISTRY

*President* :—S. S. BHATNAGAR, O.B.E., D.Sc., F.Inst.P.

# *Presidential Address*

## A SURVEY OF RECENT ADVANCES IN MAGNETISM RELATING TO CHEMISTRY.

I offer my most cordial thanks to the organizers of the Indian Science Congress for electing me President of the Chemistry Section of the Congress in the Jubilee year. It is for the second time that Calcutta has so honoured me and I am deeply conscious of this privilege. An honour like this is in itself an occasion for sincere pride, but it becomes particularly welcome when it comes from Calcutta, the cradle of the still young school of chemistry in India. Its value is further enhanced by the knowledge that I owe my elevation to this position to the self-abnegation of Acharya Sir Praphulla Chandra Ray. It is not for the first time that he has practised this kind of self-denial —his life is, indeed, a long poem in self-sacrifice.

This meeting is a great occasion in the history of the Indian Science Congress, not only because to-day it can look back on twenty-five years of proud and varied achievement, but also because we have to-day in our midst some of the most distinguished scientists of the world including representatives and members of the British Association for the Advancement of Sciences. On your behalf and on my own I extend a most cordial welcome to them. Their presence here to-day proves that in the world of science there are no barriers between the East and the West, that science can transcend racial, political and economic boundaries and that scientists all the world over are a fellowship dedicated to the pursuit of truth, to the service of humanity and to the cause of good friendship.

I am afraid that the subject of my address to-day—A Survey of Recent Advances in Magnetism relating to Chemistry—has only a rather specialized interest. But I have dared talk about this subject only, because I have been deeply interested in it for a number of years. Nor am I a lonely worker in this field. Many investigators all the world over have made this subject their own. Even in our own country there has been no dearth of workers in this field, and without making any invidious distinctions, I may be permitted to mention the names of Raman, Bose, Krishnan, Mata Prasad, K. N.

Mathur, Rai-Chaudhuri and Bhagawantam. In the international field a void has been created by the sad death of Lord Rutherford, as distinguished in the domain of Physics as in that of Chemistry, and with almost superhuman powers of discovering men of genius like Kapitza. Then there are Langevin, Weiss, Gerlach, Van Vleck, Pauling, G. N. Lewis, Stoner, Cabrera and Honda, who have enriched the science of magnetism. Though many of us have not met each other in the flesh, yet there are subtle bonds of common scientific interests between us. It is enough that all of us are workers in the field of magnetism. It is this community of interests that holds so many of us together.

Indeed, it may be claimed with some justification that it was a magnetic instrument that brought the East and the West together for Vasco da Gama, when questioned by his Emperor as to what helped him most in his voyage of exploration to the East, said without a moment's hesitation that it was the magnetic needle that had wrought the miracle.

Since the classification by Faraday [1] of substances into the now well-known ferro-, para- and diamagnetic groups and his classical researches on magneto-optics, the subject of magnetism in relation to chemistry has attracted considerable attention. Perkin [2] in a series of extensive investigations established the intimate relationship between the magneto-optical rotation and chemical constitution, while Curie,[3] Honda and Owen,[4] and Pascal [5] directed their attention particularly to those investigations which involve measurements of the magnetic susceptibility.

Necessarily the developments in magneto-chemistry have to look up to theoretical advances in magnetism for the accurate interpretation of experimental facts. Thus this subject received a fresh orientation when, after the experimental demonstration of the existence of the electrons as the constituents of the atom, Langevin [6] gave a theoretical interpretation of dia- and paramagnetism. He deduced for diamagnetic gram-atomic susceptibility an equation

$$\chi_A = -N \frac{e^2 \cdot \frac{\Sigma \overline{r^2}}{N}}{6mc^2}$$

and for paramagnetic susceptibility $\chi_M = \dfrac{\sigma^2}{3RT}$.

These equations are fundamental, though they apply strictly only to very simple molecules. The temperature independence of diamagnetism and the Curie law follow as simple consequences of the Langevin theory. For paramagnetic substances $\sigma$ gives the value of the saturation moment $N\mu$ which may be expressed in Weiss units.

Further extensive work on the magneto-chemical measurements, however, led to the conclusion that a large number both

of dia- and paramagnetic substances depart considerably from the behaviour predicted by these equations. The susceptibility of many diamagnetics varies with temperature while that of many paramagnetics increases with temperature or is constant. Again, for a considerable number of paramagnetic substances the value of $\chi_M$ is not given by Curie's equation $\frac{\sigma^2}{3RT}$ or by the Weiss equation $\frac{\sigma^2}{3R(T-\Delta)}$ for all temperatures, the relation breaking down specially at low temperatures. The agreement between the calculated values on the Langevin equation for diamagnetism and the actual experimental values is less satisfactory when molecules containing a large number of atoms are examined. Empirical correction factors depending upon the number of atoms in the molecule have, for example, to be introduced into the simple Langevin equation for calculating the susceptibility values of electronic isomers.[7]

These and many more difficulties about the behaviour of atoms, molecules, ions and complexes began to multiply as further data became available. A new light was thrown on these problems when on spectroscopic considerations Bohr introduced quantum concepts into the theory of the electronic structure of the atom which finally culminated in the formulation of the quantum theory. In this theory an electron on an orbit can be defined by four quantum numbers, viz. $n$, the principal quantum number; $l$, the angular momentum of the electron; $m_l$, the magnetic quantum number; and $m_s$, the spin. The magnetic quantum number $m_l$ represents the component of the angular momentum in the direction of the field applied. This component, which is quantized, has $2l+1$ values. The resolved value of the spin of the electron has the value $\pm\frac{1}{2}$ and is measured in terms of the quantum units $\frac{h}{2\pi}$ of the angular momentum. The electron spinning on its axis is equivalent to a circular current possessing a magnetic moment of $\frac{eh}{4\pi m \, . \, c}$ units. For one gramme-molecule this amounts to 5564 gauss$\times$cm. This unit is known as the Bohr magneton and is now universally employed at least in theoretical discussions instead of the empirical Weiss magneton.

It follows that atoms and ions which possess a resultant spin or orbital angular momentum show paramagnetism, and diamagnetism is only found in such atoms as have neither spin nor orbital momentum, i.e. possess only completed shells or sub-shells. The matter is more complicated, though not fundamentally different, in molecules. Here we have to distinguish between two kinds of shells, the 'atomic orbitals' and the 'molecular orbitals'. The atomic orbitals are the inner shells of the atoms participating in the formation of the molecule.

They belong to a particular nucleus and remain practically unaltered, the interaction between those belonging to different nuclei being negligible and that between them and the molecular orbitals being reduced to a mere screening effect. Therefore they are of no account in deciding whether a molecule is paramagnetic or diamagnetic. The molecular orbitals are formed by the valency electrons of the atoms participating in the formation of the molecule which are under the influence of two or more nuclei.

In diatomic molecules the quantum number $\lambda$ characteristic of those orbitals does not measure the orbital momentum itself, as does $l$ (or $L$) for atoms, but measures its component in the direction of the molecule axis. The molecular orbitals are complete with 2 or 4 electrons respectively. If a diatomic molecule with an even number of electrons contains only complete orbitals, both spins and $\lambda$'s are counter-balanced, and it is diamagnetic. If a molecule has an odd number of electrons, at least one orbital is bound to be incomplete, the spins cannot be counter-balanced, and the molecule is paramagnetic. If a diatomic molecule has an even number of electrons, but not complete molecular orbitals (e.g. when an orbital, whose maximal population is 4, contains only 2 electrons), both diamagnetic and paramagnetic configurations are possible, and a consideration of each individual case is necessary to determine whether the ground-state is paramagnetic or diamagnetic.

The matter is still more complicated in polyatomic molecules. This is not the place to deal in detail with this extensive subject, but it may be said briefly that molecules with an even number of electrons and no free valencies are diamagnetic, and that molecules with an odd number of electrons are paramagnetic. Since a free valency is caused by an electron, whose spin is not counter-balanced by that of another electron, and since therefore a free valency is always accompanied by paramagnetism, also such molecules with an even number of electrons are paramagnetic as contain an even number of free valencies, as, for instance, the bi-radicals.

Such considerations led to a rational interpretation of the data which had accumulated on the subject. For example, the values of the magnetic moments of atoms, as observed by Stern-Gerlach technique, received an immediate interpretation. The behaviour of some of the complexes, the Bohr magneton values of rare earth ions, the diamagnetism of rare gases and of a large number of organic compounds and ions of the type $Na^{\cdot}$, $K^{\cdot}$, $Sr^{\cdot\cdot}$, $Ca^{\cdot\cdot}$, $F'$, $Cl'$, $S''$, etc. were all satisfactorily explained. The important gaps such as those in connection with the susceptibility results of the ions of the first transition series, which still remained inexplicable on the simpler theory, were gradually filled in, notably by such theories as that of Stoner,

who introduced the concept of a crystalline field arising out of the interaction between ions and the surrounding molecules.

A new outlook was given to the subject by the development of wave mechanics. This resulted in a number of attempts to modify and extend the Langevin equations on the new basis, notably by Van Vleck,[8] with a view to the correlation of a wider range of experimental facts.

In the Langevin equation for diamagnetics, the principal difficulty lies in fixing the value of the radius of the electronic orbit, particularly for a complex ion where the nuclear change is rendered much less effective on account of the screening effect of the electrons in lower levels. Pauling,[9] Slater,[10] Stoner,[11] Angus [12] and others have developed theoretical methods for calculating the value of the screening constants, or, more generally, of the charge distributions in atoms and ions, and have obtained satisfactory values for the magnetic susceptibility by introducing the figures into the fundamental equations. These modified equations, however, though in themselves a great advance, fail to give in many cases a completely satisfactory agreement with experimental facts.

Refinements have also been introduced into the Langevin equation for paramagnetics and attempts have been made to explain the feeble paramagnetism independent of temperature exhibited by some substances. According to the views of Van Vleck,[13] paramagnetism in a system is made up of three terms, viz. (*a*) a contribution of the low frequency matrix elements to paramagnetism identical with the Langevin formula and dependent on temperature, (*b*) the contribution of high frequency element to paramagnetism independent of temperature, and (*c*) underlying diamagnetism independent of temperature. This treatment of paramagnetism refers only to atoms with Russell-Saunders (*L-S*) coupling. For different normal states of the atoms, the angle between *L* and *S* would be different, necessitating a different magnetic moment for these states. The theory of Van Vleck is capable of taking these facts into consideration and thus constitutes a distinct advance on the original Langevin hypothesis of a system possessing a permanent moment.

In this necessarily brief and mainly chemical treatment of the subject it is not possible to refer at any great length to the fascinating subject of ferromagnetism which is exhibited by iron, cobalt, nickel and a number of special alloys and steels at ordinary temperatures. A number of attempts, especially by Heisenberg,[14] Bloch,[15] Stoner,[16] Mahajani,[17] Gans,[18] Akulov,[19] Becker,[20] Dorfmann [21] and others have been made to explain this behaviour and are fully described in various text-books. Of special interest to the chemist, however, is the very common, small and approximately constant paramagnetism of metals and alloys which has found interpretation in terms of the properties of collective electrons.

The rapidity with which the subject of magnetism in relation to chemistry has grown, may be judged from the fact that three books [22] on the subject have appeared during the years 1934-35. Even in the short period which has elapsed since the appearance of these books, there has been an almost encyclopædical output of work on magneto-chemical problems. Like any other healthy and growing subject, advances in this field have reacted on the contemporary subjects and the contemporary advances have in turn been responsible for fresh developments in magneto-chemistry. In this survey the subject of magneto-chemistry has been treated under the following heads :—

1. Magnetic moments and nuclear chemistry.
2. Magnetic properties of free atoms and molecules.
3. Magnetic properties of elements.
4. Molecular diamagnetism.
5. Paramagnetism of molecules, free radicals and bi-radicals.
6. Polymerization.
7. Magnetic properties in relation to phase equilibrium.
8. Influence of the magnetic field on homogeneous and heterogeneous equilibria.
9. Catalysis and magnetic properties.
10. Magneto-optical analysis.
11. Photomagnetic effect.

## 1. Magnetic Moments and Nuclear Chemistry.

With the discovery of the neutron and the positron as definite physical entities, Heisenberg's theory of the neutron-proton constitution of the nucleus was put on a firm experimental basis. The older theory of proton-electron constitution of the nucleus had to be rejected on the consideration of (*a*) the application of Bose and Fermi statistics, (*b*) the size of the electron wave function, and (*c*) the impossibility of a potential barrier sufficient to keep the electron inside the nucleus.[23] If both the protons and the neutrons be supposed to have a mechanical spin 1/2, then the resultant of nuclear spins for an atom (protons and neutrons constituting the nucleus) will be integers or half integers, according as whether there is an even or odd number of elementary particles. This conclusion from the vector model of the quantum theory is in accord with the observation. Furthermore, nuclei with mechanical moments will have magnetic moments of the order $\frac{1}{2} \cdot \frac{h}{2\pi} \cdot \frac{e}{m_0c}$ or $\frac{1}{2} \frac{h}{2\pi} \frac{e}{Mc}$ (where $m_0$ and $M$ are the masses of the electron and the proton respectively) associated with them according as whether or not there is any electron inside the nucleus. But it has been found that the nuclear magnetic moments are all of the order

of $\frac{1}{2}\frac{h}{2\pi}\frac{e}{Mc}$ (usually taken as the unit of nuclear magnetic moment) precluding thereby the possibility of the existence of electrons inside the nucleus. This makes it difficult to explain the emission of the $\beta$-particles in the $\beta$-ray decay of radio-active elements. This was accounted for by suggesting that electrons are formed just before the $\beta$-rays are emitted. In order to avoid the difficulties connected with conservation of energy and angular momentum, a simultaneous emission of a neutrino—a hypothetical particle with no charge and with a mass equal to or less than that of the electron—has been suggested. The neutrino like any elementary particle is assigned a spin 1/2 and the Fermi statistics.[24] Such a particle should have a magnetic moment associated with its spin and as shown by Bethe[25] should produce 100 $n^2$ ions per kilometre of its path, where $n$ is the magnetic moment in Bohr units. Nahmias[26] investigated the ionization produced by neutrinos shot out from a carefully shielded radio-active source and concluded that the magnetic moment of neutrinos, if at all it exists, is smaller than 1/7000 Bohr unit. It is more probable that the neutrino has no magnetic moment at all and it is useless to search for it by this method.

As has been pointed out, the nuclei have mechanical spins associated with them. A very striking fact is that although heavy atoms are composed of a large number of particles, the greatest value for the spin observed is 9/2 and the majority of values are much smaller. This would be possible, if the neutrons and protons occur in the form of closed shells analogous to the completed electronic groups, so that the spin is contributed by the outermost neutrons and protons only. The problem, though complicated on account of the presence of a large number of particles, becomes on the whole analogous to that of the spin contribution of the electrons in extra-nuclear orbits.

It has been found that with these assumptions it is possible to account for the spin values of the nuclei of atoms of all the four types, viz. with odd and even nuclear charges having odd or even atomic weights.

The theory of closed neutron and proton shells calls for a scheme of distribution of these particles in various levels. White,[27] Gapon and Iwanenko,[28] Bartlett[29] and others have suggested schemes more or less analogous to those for the distribution of electrons in various orbits. According to the latest system of notation first are given the configurations of protons, then those of the neutrons followed by the characteristic level of the nucleus as a whole. According to this scheme the total orbital momentum of the nucleus is denoted by $\Lambda$ and total spin momentum by $\Sigma$ whose resultant is the nuclear spin $I$ (total angular momentum of the nucleus). This essentially involves the assumption of Russell-Saunders coupling for the

nuclei. Thus a term $(1s^2 2p \,.\, 1s^2 2p^2)^2 P_{3/2}$ signifies 2 and 1 protons in the $1s$ and $2p$ shells and 2 neutrons each in $1s$ and $2p$ shells respectively. The resultant orbital momentum is 1 ($P$ term), the resultant spin 1/2 (doublet term) and the total nuclear moment 3/2. By a complicated process essentially similar to that used in the optical spectra it is possible to calculate the energy of various levels corresponding to a given configuration of protons and neutrons.

The total nuclear spin or the mechanical moment ($I$) gives rise to the nuclear magnetic moment ($\mu$) and the magnitudes of these two are related to one another by the simple equation: $g \,.\, I = \mu$. The magnetic moment of the nucleus combines with the magnetic field produced by the electrons and with the orbital moment to give rise to the hyperfine structure. The absence of hyperfine structure therefore indicates the absence of a nuclear magnetic moment.[30] This may be due to a small '$g$' factor for atoms with a definite integral moment or to a zero spin. A decision on this point may be obtained from the measurement of the alternating intensity of the lines forming the rotational structure of the band spectrum.

Like the mechanical moments, the nuclear magnetic moments also are related to the constitution of the nuclei. Nuclei with both atomic numbers and atomic weights odd have magnetic moment values positive and greater than I, while those having atomic numbers even and atomic weights odd have small and generally negative magnetic moments. Similarly nuclei with atomic numbers odd and atomic weights even have small and positive magnetic moments, while those with both atomic weight and atomic number even have zero values for magnetic moments.

The nuclear mechanical and magnetic moments are thus intimately related to the constitution of the nuclei although it must be admitted that the theory is not yet very much advanced. Experimental determination of these values has also of late attracted considerable attention and the following methods have been developed to determine especially the '$g$' value.

(*a*) *Hyperfine structure.*—This method is due to Goudsmit,[31] who has deduced equations showing the relation between donblet separation and '$g$' factor, both for penetrating and non-penetrating electronic orbits. This methed has the advantage that it is possible to get the '$g$' value and the nuclear magnetic moment both for the normal and excited atoms. It is also possible by this method to get the ratio of the magnetic moments of two isotopes. Its only limitations are the complexities of the patterns and very small separations. Amongst the most successful determinations of magnetic moments in this manner are those for $Sc^{45}$, $Cs^{133}$ $Li^{6}$, $Li^{7}$, $K^{39}$, $Na^{23}$, Cu isotopes, Sb isotopes, etc.

(*a*) ***Polarization of resonance radiation.***—Ellett and Heydenburg [32] have developed a method of determining the hyperfine

separations by observing the change in the intensity of the radiation from atoms in a magnetic field. Even if the polarized components cannot be resolved the change in intensity is evident in the polarization of the emitted radiation. By this method very small hyperfine separations for Cs and Na have been determined.

(*c*) *Atomic and molecular beam.*—The original method of Stern and Gerlach [33] of passing a beam of neutral particles through a non-homogeneous magnetic field with a steep gradient and placed at right angles to the path has been modified by Stern, Estermann and Frisch.[34] It has been employed in particular for measuring the magnetic moment of the proton by carrying out experiments with *para*- and *ortho*-hydrogen.[35] The value of 2·5 nuclear magnetons obtained by this method is surprisingly large for the proton but is comparable with the value 2·9 obtained from hyperfine separations.[36] (On Relativity considerations, Wataghin [37] has obtained the value of 3 nuclear magnetons for the proton.) An extremely ingenious modified form of the atomic beam method has been developed by Rabi [38] and employed in the determination of the nuclear moments of the alkali metal atoms.

(*d*) *Other methods.*—(i) The *p*-, *o*-conversion of hydrogen and of deuterium has been found by Farkas and Farkas [39] to be catalyzed by a non-homogeneous magnetic field as provided by an oxygen molecule. From the velocity of conversion of *p*-hydrogen and deuterium into the *o*-variety these authors have deduced the ratio of the nuclear magnetic moments $\mu_p/\mu_D$ to be $3{\cdot}96 \pm 0{\cdot}11$.

(ii) By passing a beam of particles through two sets of magnetized iron bars used as analyzer and polarizer respectively, and placed at an angle relative to each other, Frisch, Halban and Kosch [40] have developed a method for finding out the direction of precession of the particles under examination. By a slight modification of this method it is possible to determine the sign of the magnetic moment of the neutron which is shown to be negative, as if the particle carried a negative charge. This is in agreement with the indirect value deduced for the neutron from the observed magnetic moments of deuteron and proton.

## 2. Magnetic Properties of Free Atoms and Molecules.

The earlier work by the atomic beam deflection method on the atomic moments of Zn, Cd, Hg, Pd, Sn, H, Pb, Li, Na, Cu, Ag, Au, Tl, etc. is in entire agreement with theoretical predictions based on spectroscopic grounds. The same applies to the work done during the period under review. Oxygen atoms [41] in an electrodeless discharge yielded a value of 1·67 Bohr magnetons

as compared to 1·71 Bohr magnetons deduced from intensity distribution curves. In the case of Bi, Leu[42] obtained an undeflected beam at a temperature of 1183°A, in spite of the ground-state of bismuth being $^4S_{3/2}$. This was attributed to the presence of $Bi_2$ molecules. At higher temperatures, however, a symmetrical deflection pattern was obtained corresponding to $\mu_B = 0{\cdot}72$. The '*g*' value obtained from the value of the atomic magnetic moment lies between the one calculated for Russell-Saunders coupling and that for *jj* coupling.

The outstanding discrepancy in the earlier work on magnetic moment was for iron, nickel and cobalt atoms.[43] In the case of the first two elements an undeflected pattern was obtained in contradiction to the spectroscopic prediction. Recent careful work by Klabunde and Phipps[44] has, however, shown that the magnetic moment of the iron atom is 2·03 Bohr magnetons and not zero as previously obtained by Gerlach.

The elements of the sixth group of the Periodic Table (Oxygen, Sulphur, Selenium, Tellurium) are particularly interesting, because their diatomic molecules have two valency electrons in an incomplete shell and therefore possess a diamagnetic $^1\Sigma$ and a paramagnetic $^3\Sigma$ state. As to oxygen it has been established for a very long time both by spectroscopic and magnetic evidence, that of the two states mentioned $^3\Sigma$ is the lower one, thus rendering the oxygen gas paramagnetic. Wiersma and Gorter[45] showed that its paramagnetic susceptibility is influenced by pressure, the lower value of $\chi$ at higher pressures being probably due to the destruction of paramagnetism on account of the formation of diamagnetic $O_4$ molecules. The same applies to sulphur, selenium and tellurium in the vapour state. Although their polyatomic molecules are diamagnetic, their diatomic ones have both $^1\Sigma$ and $^3\Sigma$ states. It has been established by spectroscopic evidence that in $S_2$ vapour also the $^3\Sigma$ state is the lowest one, thus causing it to be paramagnetic. This was confirmed by the magnetic measurements of Néel.[46] There is a chance that in the heavier elements of this group the $^1\Sigma$ level may come below the $^3\Sigma$ level, thus rendering the diatomic vapour diamagnetic. Spectroscopic investigations have so far not been able to bring about a decision, but magnetic measurements carried out at Lahore[47] have shown that $Se_2$ vapour is paramagnetic and therefore has a $^3\Sigma$ ground-state like $O_2$ and $S_2$. Corresponding results on $Te_2$ are not yet available.

Bromine vapour was examined by Shur and Yanus.[48] Its susceptibility ($-0{\cdot}46 \times 10^{-6}$) is in agreement with the theoretical value.

Based on the measurements of Roth, Gerlach[49] has given the value of the molar susceptibility of argon to be $-19{\cdot}7 \times 10^{-6}$ and shown it to be constant between 290° and 700°C. Mann[50] has also measured the values for the other inert gases, Ne, Kr

and X, and found them to be substantially in accord with the theoretical ones.

The molecular states of iodine have been determined in various solvents in the author's laboratories [61] and it has been concluded that while iodine ionizes in carbon disulphide and benzene, it probably continues in the molecular state in *cyclo*-hexane.

### 3. Magnetic Properties of Elements.

*Susceptibility of elements en masse.*—The magnetic properties of substances in the solid or liquid state differ from those of free molecules in so far as owing to interaction with neighbouring molecules or atoms a structural influence is super-imposed on the molecular magnetism.

In special cases like that of the rare earths it is still possible to draw conclusions regarding magnetic moments from measurements of the solid substance. For instance, the magnetic moments of the atoms of cerium and praseodymium [52] have been obtained by investigating their susceptibility as function of the temperature. Besides these two rare earths, lanthanum, neodymium [53] and gadolinium [54] have also been studied. In some cases the susceptibility appears to be affected by the field strength, presumably on account of ferromagnetic impurities. All of them follow the Curie-Weiss law with the exception of gadolinium and possibly of cerium. Gadolinium is ferromagnetic with a Curie temperature of 16°C., the low temperature saturation moment per atom being greater than that of iron. The behaviour of cerium is still under dispute.

There is, however, one remarkable fact about the rare earths. The magnetic moment of trebly ionized Gd can be theoretically calculated, being 39·26 Weiss magnetons, and is in exact accord with the value 39·28 Weiss magneton measured for the metal. This strange agreement between the atom and its ion is more or less common to all the elements of the rare earth group. Stoner [55] has tried to make this plausible by pointing out that probably the whole of the paramagnetism both of atoms and ions is due to the incomplete $4f$ shell, which is common to either of them, and that the contribution of the 3 valency electrons of the atoms is of minor importance owing to their becoming collective electrons in the metal. Definite proof is still wanting, but this suggestion is so interesting that further investigation appears to be worth while.

Prins [56] and later Coffin [57] examined an amorphous form of antimony, more popularly known as 'explosive antimony'. The latter author reports the value of the susceptibility to be $-0{\cdot}38\times10^{-6}$ as compared to $-0{\cdot}88\times10^{-6}$ for crystalline antimony. He has also shown that explosive antimony should be regarded as a super-cooled liquid. The non-metallic nature of

explosive antimony may, according to Coffin, be due to the change of the metallic bond to the homopolar one.

Bates and Baqi [58] have measured the magnetic susceptibility of chromium over a range of temperature and shown its value to be constant. This is an interesting illustration of paramagnetism being independent of temperature.

Measurements on manganese carried out by Bates and Pantulu [59] indicate that its very high paramagnetism is not to be found in the amorphous variety, thus indicating that high paramagnetism is associated with the crystal structure. Bates, Pantulu and Gibbs [60] have extended this work to the measurement of the magnetic susceptibility of Mn heated to different temperatures in an atmosphere of nitrogen and have found that ferromagnetism is developed in samples, which, as shown by their X-ray spectrum, are in the $\gamma$ phase and have an enlarged lattice.

The magneto-chemical behaviour of rhenium has also attracted attention. Its specific magnetic susceptibility has been measured by Perrakis and Karatos [61] and found to be $0{\cdot}046 \times 10^{-6}$ in accord with the value $0{\cdot}040 \times 10^{-6}$ in the heptavalent state.[62] This agreement, unless due to an experimental error, shows at the same time, that the rhenium compounds chosen by the authors were in a covalent state of combination.

Lane [63] investigated the magnetic behaviour of barium as a function of temperature and showed that its specific magnetic susceptibility increases from $0{\cdot}147 \times 10^{-6}$ at 20° to $0{\cdot}415 \times 10^{-6}$ at 400° with a break at 350°, which agrees with the temperature of discontinuity of electric resistance observed by Rinck.[64] This behaviour suggests a change of the crystalline modification, but since it is inconsistent with the results reported before, it should be followed up.

A good deal of controversy still exists regarding the susceptibility of mercury in the liquid state. Honda [65] obtained a value of $-0{\cdot}19 \times 10^{-6}$, whereas measurements of Bates and Tai [66] yielded a value of $0{\cdot}1676 \times 10^{-6}$. This is also in agreement with the average value of $-0{\cdot}172 \times 10^{-6}$ found in the Lahore laboratories [67] for mercury from various sources, but disagrees with the susceptibility of mercury vapour. The vapour was investigated by Shur,[68] who found its susceptibility to be $-0{\cdot}389 \times 10^{-6}$; theoretical considerations of Slater yielded $-0{\cdot}42 \times 10^{-6}$. The disagreement between the values for the liquid and the vapour states is probably due to mercury forming polyatomic molecules in the liquid state.

Mention must be made of the work on bismuth, which on account of its abnormal diamagnetism and other magnetic anomalies has been a centre of interest both theoretically and experimentally.

The bismuth crystal has a layer lattice with homopolar linkages within the layers and metallic ones in the direction perpendicular to it and therefore is bound to exhibit certain

peculiarities. Goetz and Focke [69] have made extensive investigations on its anomalous diamagnetism, the influence of temperature and the presence of foreign atoms in the lattice. With the help of Bloch's lattice theory, Jones [70] was able to explain the formation of the layer lattice and the anomalies in diamagnetism and magnetostriction. A theory of the magnetostriction of single crystals of Bi was also advanced by Kapitza [71] and formulæ for the magnetostriction of trigonal Bi have been developed by Shoenberg.[72] Kapitza's experimental results [73] on magnetostriction of bismuth have been confirmed by Wolf and Goetz,[74] Goetz and Focke [75] and Shoenberg.[76]

Perhaps the outstanding event in the work on bismuth is the De Haas-Van Alphen Effect. De Haas and van Alphen [77] found that at temperatures 20·4°K and 14·2°K a decrease of magnetization occurred, when the field exceeded 12,500 gauss, if perpendicular to the diagonal axis, and 14,500 gauss, if parallel to it. At higher field strength the magnetization is again normal. Measurements of Shoenberg and Zakiuddin [78] confirmed these results and a theory of the effect has been proposed by Peierls.[79]

*Magnetic anisotropy.*—An increasing amount of attention has been paid to the exact determination of the values of susceptibilities along different axes in a crystal. It is mainly due to the work of Krishnan [80] and Mrs. Lonsdale [81] that these determinations have been made the basis of an auxiliary method for determining the structure of crystals. Nilakantan [82] has, for example, studied rhombic sulphur and shown that the X-ray plan of a puckered-ring-shaped molecule consisting of 8 atoms and oriented with the plane parallel to the *c*-axis of the crystal is confirmed by the magne-crystalline data. The magnetic data, however, give the inclination of the plane of the ring to the *a*-axis to be about 70° instead of 50° as suggested by X-ray analysis.

Krishnan and his collaborators [83] have also studied the case of graphite and shown that the high diamagnetism, displayed by it in the direction normal to the basal plane and resulting in the high anisotropy, is expected from the characteristic layer lattice structure of the crystal. The weak bond between the successive layers is supposed to be of the metallic type as contrasted with the comparatively stronger homopolar bonds in the plane of the ring. Ganguli [84] has further shown that the high anisotropy of graphite falls considerably when it is oxidized to blue graphite. Presumably this is brought about by the metallic linkage between the layers getting broken and being utilized in fixing up the oxygen. A further stage in oxidation results in the breaking up of covalent links so that the hexagonal network of carbons breaks up into discrete benzene rings.

Use has been made of these observations of Ganguli and of the workers in Lahore [85] in elucidating the nature of the activation

of carbon. It has been shown that this process consists in the development on the surface of carbon of graphitic crystals differentially oxidized.

Study of the magnetic properties of single crystals, particularly of bismuth, thallium, lead, tin, mercury and some ferromagnetic metals, has also been made and much valuable information regarding the structure and other physical properties has been obtained.

*Magnetic susceptibility and particle size.*—A problem which has aroused considerable interest is the influence of particle size on the magnetic susceptibility. Rao [86] observed a decrease in the diamagnetic susceptibility of elements like Bi, Sb and graphite and an increase for others like Sn and Cu. Attention was drawn early by the present author to the fact that the observed effects may be due to surface oxidation, adsorption of gases,[87] etc. or to a change in the microcrystalline structure on colloidalization.[88] From a series of carefully planned experiments involving a rigorous control of the method of preparation of elements, their powdering, grading and chemical examination, it was shown that there is no effect of the particle size on magnetic susceptibility in the case of Bi,[89] Sb,[90] S, Se, Te, Pb, Cu[91] and Sn[92] down to about $0{\cdot}4\mu$. Lessheim[93] has discussed the subject at some length and has summarized the experimental evidence available and concluded that the results are in agreement with the author's point of view.

Where chemical changes are excluded the observed changes in magnetic susceptibility have been shown to be due to the change in the microcrystalline structure. Prins [56] has, for example, established that the explosive form of antimony, which is amorphous in nature, has a much lower magnetic susceptibility than the crystalline variety. Measurements on red and yellow oxides of mercury in the author's laboratories [94] showed that the magnetic susceptibility of the two varieties is identical, while the susceptibility values for the red and yellow oxides of lead are different. The structure of the two oxides of mercury has been shown to be identical. The difference in colour arises on account of the difference in the state of aggregation. The two oxides of lead have, on the other hand, a different crystalline arrangement. The magnetic behaviour of the two sets of oxides is thus satisfactorily accounted for.

Rao [95] has recently extended his work and shown that cold-stretching also involves a change in the magnetic susceptibility and concludes that the particle size effect observed by him is analogous to that observed on cold-stretching. It may be pointed out that cold-stretching involves a forcible change or at least severe distortion of the crystal structure. Such an effect should of course involve a change in the magnetic properties.

## 4. Molecular Diamagnetism.

We shall now refer to molecular diamagnetism, which constitutes perhaps the most important chapter in magnetism in relation to chemistry. As a result of extensive systematic investigations of the magnetic properties of non-polar organic compounds, Pascal discovered the principle of additivity of diamagnetic properties of these substances. The molecular susceptibility $\chi_M$ could be closely represented as $\chi_M = \Sigma\chi_A + \lambda$ where $\Sigma\chi_A$ represents the sum of the atomic susceptibilities of all the atoms in the molecule and $\lambda$ is the constitutive constant depending on the nature of the linkages between the atoms. Thus the effect of double bonds, ring formation or strongly polar groups was generally found to lower the diamagnetism of the whole molecule.

Pascal's values have been shown to be generally fairly accurate, but a critical study of his data shows that a re-examination of his values is necessary, e.g. the value $-11{\cdot}86 \times 10^{-6}$ for the $CH_2$ group obtained by Pascal from a large number of substances differs considerably from his own value $-11{\cdot}42 \times 10^{-6}$ deduced from nitro compounds. With the aid of the magnetic interference balance, Mitra and Tuli [96] obtained a value of $-11{\cdot}36 \times 10^{-6}$ for the $CH_2$ group from a study of various homologous series, which is in accord with that of Pascal for compounds with a nitro group. The lower experimental value for $CH_2$ gives a value $-2{\cdot}68 \times 10^{-6}$ for $\chi_{H_2}$. This value is in better agreement with the theoretical value of $-2{\cdot}37 \times 10^{-6}$ than with the value $-2{\cdot}98 \times 10^{-6}$ which was deduced from Pascal's data.

Gray and Cruickshank [97] have, however, obtained a value of $-11{\cdot}87 \times 10^{-6}$ for the $CH_2$ group from an investigation of three different homologous series of organic nitrates, nitrites and nitro compounds. The nitrates and nitrites were not studied by other workers as they are difficult to obtain in a pure state. It is evident that owing to developments in the theory a more exact determination of the $CH_2$ group in various states of combination is desirable.

On the additivity law the susceptibilities of organic isomers would be expected to be identical, but recent measurements [98] have shown that small and definite differences exist between different organic isomers, for example, for aliphatic isomerides, the susceptibility increases in the order: primary, secondary and tertiary; for aromatic isomerides, the ortho forms have the highest susceptibility.

Pascal determined the value of the constitution correction factor $\lambda$ for a large number of organic compounds. Recently useful addition to this has been made by Kapur and Verma [99] in my laboratories who have determined the $\lambda$ value for that class of organic compounds known as addition compounds. $\lambda$ was found to have a specific value for different compounds,

which depends on the nature of the various substituents and groups present. Kido[100] has also recently studied the effect on susceptibility of replacing various groups in many compounds.

Whether or not the additivity law of Pascal holds good for polar compounds as well, has been the subject of investigation of various workers during recent years. An extensive study of inorganic compounds by Kido,[101] Flordal,[102] Subramaniam[103] and the work carried out in the writer's laboratory[104] shows that in electrovalent salts, where the ions have complete inert gas configuration, the molecular susceptibility can be considered to be the sum of the ionic susceptibilities which constitute the molecule, but in compounds like $HgCl_2$, $CdI_2$ the values obtained are slightly higher, and this may be due to their being covalent. Moreover, it has been observed that the susceptibility of an ion in a dissolved state is higher than in the solid state. This deviation is due to the assumption in calculations that neither the solvent nor the solute undergoes any change and the ions behave as perfectly free ions. But from Farquharson's work[105] on acids and from theoretical considerations the higher ionic susceptibility values in solutions have been shown to be due either (*a*) to the deformation of the electronic system of the molecules by the polarizing action of the molecules of the solvent to the extent of producing more dissociation, (*b*) to the formation of polymers, or (*c*) to the depolymerization of the solvent molecule. Thus whenever any of the above-mentioned complications would arise, the ionic susceptibility value would not vary linearly with the concentration. The formation of hydrates and other complexes in solutions can therefore be ascertained by determining the ionic magnetic susceptibility values, and this has been done by a number of workers.

Many attempts have been made during recent years to ascertain the validity of various expressions for atomic or ionic susceptibilities, put forward by Pauling,[9] Van Vleck,[106] Slater[10] and Angus[12] on theoretical considerations. The results obtained in the writer's laboratory showed, in general, that there is a close agreement between experimental ionic susceptibility values and those calculated according to Slater's and Angus's methods.

Several workers have also utilized the plans proposed on quantum mechanical considerations to elucidate the structure of diamagnetic compounds. Varadachari and Subramaniam[107] determined the susceptibilities of a number of sulphur compounds in solution and by comparing them with the values obtained on theoretical considerations assigned different valencies to sulphur in different compounds. Farquharson[108] similarly studied the magnetic behaviour of sulphur trioxide, potassium bisulphate, potassium sulphite, potassium thiosulphate, potassium persulphate, potassium pyrosulphate and potassium tetra-thionate and determined according to Pauling's and Slater's plan the

polarity of some of the linkages. Although applied with success to cases where the compound behaved either as a perfect electrovalent or as a covalent one, the various plans for the elucidation of the structure have not so far been successful in cases where there is partial dissociation.

Gray and Cruickshank [97] have put forward a new plan based on that of Pascal, and utilizing Pauling's theoretical results, for studying the structure of diamagnetic molecules. They have calculated the 'depression' of diamagnetism for various bonds in different compounds. The plan is a great advance in the elucidation of structure, because it helps in differentiating between different structures including those involving resonance, and can be applied to cases for which no method has hitherto been available. One of the interesting cases which has been discussed by these authors is that of hydrogen peroxide. Hydrogen peroxide has been commonly assigned structures I and II.

$$\begin{array}{l} {}^{a}H \diagdown \\ \qquad > \underset{c}{O} \rightarrow \underset{d}{O} \\ {}^{b}H \diagup \end{array} \qquad\qquad \overset{a}{H}-\overset{b}{O}-\overset{c}{O}-\overset{d}{H}$$

I. II.

The experimental value for the molecular diamagnetism has been found to be $-16{\cdot}73 \times 10^{-6}$. The values of the structural molecular diamagnetism for the formulæ I and II as calculated on Gray and Cruickshank's plan are 17·75 and 17·55 respectively.

The difference, 1·02, between the calculated molecular diamagnetism for the structure $\begin{array}{l} H \diagdown \\ \quad > O \rightarrow O \\ H \diagup \end{array}$ and the experimental value may be accounted partly to the polymerization and partly to the depression due to co-ordinate bond O→O. The depression for O→O is 0·6 and the remaining 0·42 value can be reasonably ascribed to polymerization. According to the other formula the difference between the calculated and the observed value is 0·82. This structure contains the covalent link O—O which probably gives a depression greater than 2. There would be some depression due to polymerization as well. Thus the difference 0·82 is much less than that which would be due both to the polymerization and to the O—O link.

Accordingly these results clearly give support to the formula:

$$\begin{array}{l} H \diagdown \\ \quad > O \rightarrow O. \\ H \diagup \end{array}$$

The structures for benzene, naphthalene, acid carboxyl and water assigned on the new plan show close quantitative agreement with the diamagnetic data.

Recently Clow [109] has applied this plan to the study of the much debated structure of urea and its derivatives. Several structures including the simple carbamide and the cyclic structure proposed by Werner [110] have been suggested to account for their various physical and chemical properties. With the introduction of the concept of quantum mechanical resonance Pauling [111] suggested that urea and some of its derivatives should be represented by resonance structure. The carbamide structure can resonate between

$$\begin{array}{c} \mathrm{H_2N : \underset{\cdot\cdot}{C} : NH_2} \\ \underset{\cdot\cdot}{\ddot{\mathrm{O}}}: \end{array} \rightleftharpoons \begin{array}{c} \mathrm{H_2N : \underset{\cdot\cdot}{\overset{+}{C}} : NH_2} \\ :\underset{\cdot\cdot}{\mathrm{O}}:^- \end{array}$$

while the amino-imino structure presents a second possible type due to resonance in the C : : N group

$$\begin{array}{c} \mathrm{H_2N : \underset{\cdot\cdot}{C} : OH} \\ :\ddot{\mathrm{N}} : \mathrm{H} \end{array} \rightleftharpoons \begin{array}{c} \mathrm{H_2N : C \overset{+}{:} OH} \\ :\underset{\cdot\cdot}{\overset{\cdot\cdot\,-}{\mathrm{N}}} : \mathrm{H} \end{array}$$

The cyclic structure proposed by Werner can resonate when represented as 'zwitterion' or the so-called hybrid ion

$$\begin{array}{c} \mathrm{HN : : C : \overset{-}{O}} \\ \overset{\cdot\cdot\,+}{\mathrm{NH_3}} \end{array}$$

$$\begin{array}{c} \mathrm{H : \overset{\cdot\cdot}{N} : : C : \overset{-}{O}} \\ \overset{\cdot\cdot\,+}{\mathrm{NH_3}} \end{array} \rightleftharpoons \begin{array}{c} \mathrm{H : \underset{\cdot\cdot}{\overset{\cdot\cdot\,-}{N}} : \underset{\cdot\cdot}{\overset{+}{C}} : \underset{\cdot\cdot}{\overset{\cdot\cdot\,-}{O}} :} \\ \overset{+}{\mathrm{NH_3}} \end{array}$$

The calculated resultant magnetic susceptibility for the three possibilities are 27·46, 31·69 and 33·35, respectively, against the experimental value 33·56. It is clear that the resonating 'zwitterion' formula agrees with the experimental value. This is therefore a strong evidence in favour of the resonating zwitterion which is an extension of the cyclic structure of Werner.

Since the discovery of heavy hydrogen, much interest has been shown in its compounds specially in the measurement of their physical constants. This is all the more so on account of the fact that the compounds of heavy hydrogen have ceased to be chemical curiosities and are entering more and more into the every-day life of the organic and inorganic chemist. One of the most useful additions to the physical data of the subject has been the exact determination of the value of the magnetic susceptibility of heavy water. Some of the most recent and reliable data available at present are tabulated below :

| Author. | % of $D_2O$ employed. | $-\chi \times \cdot 10^{6}$. |
|---|---|---|
| Hoare [112] .. .. | 99·2 | 0·648 ± 0·004 |
| Selwood and Frost [113] . | 92·0 | 0·644 |
| Cabrera and Fahlenbrach [114] .. | 99·0 | 0·637 |
| Trew and Spencer [115] .. | 99·2 | 0·637 ± 0·07 |
| Nehra and Qureshi [116] .. | 99·5 | 0·638 |

Iskenderian [117] has also recently carried out measurements with $D_2O$ and HDO and found the values for their specific susceptibilities to be $-0{\cdot}6466\times10^{-6}$ and $-0{\cdot}6807\times10^{-6}$ respectively as compared with $-0{\cdot}72\times10^{-6}$ for $H_2O$. The molecular susceptibilities for $D_2O$ and $H_2O$ on these data are $-12{\cdot}95\pm0{\cdot}01\times10^{-6}$ and $-12{\cdot}97\times10^{-6}$ respectively, which are practically identical.

## 5. Paramagnetism of Ions, Molecules, Free Radicals and Bi-Radicals.

As regards the paramagnetic molecules, the electronic theory of atomic structure assigns the paramagnetism of an ion

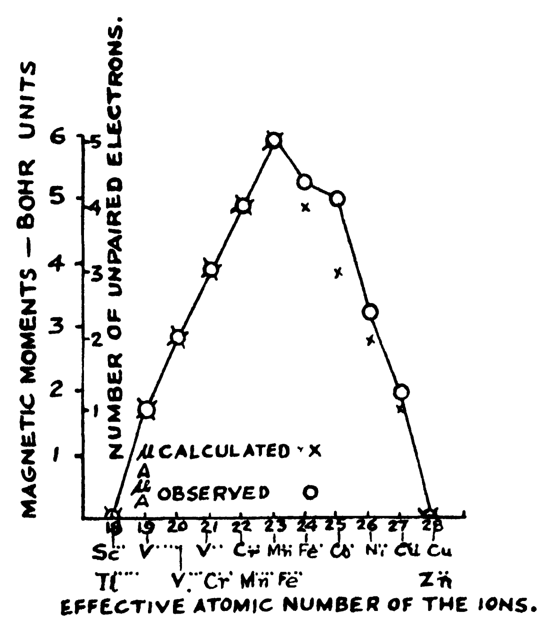



Fig. 1.

either to the orbital angular momentum of an incomplete electron shell or to its resultant spin. In accordance with this the experimental results have shown that the ions of the transition series and of the rare earths are paramagnetic. The ionic susceptibilities of the elements of the first transitional series are given more or less satisfactorily by the expression

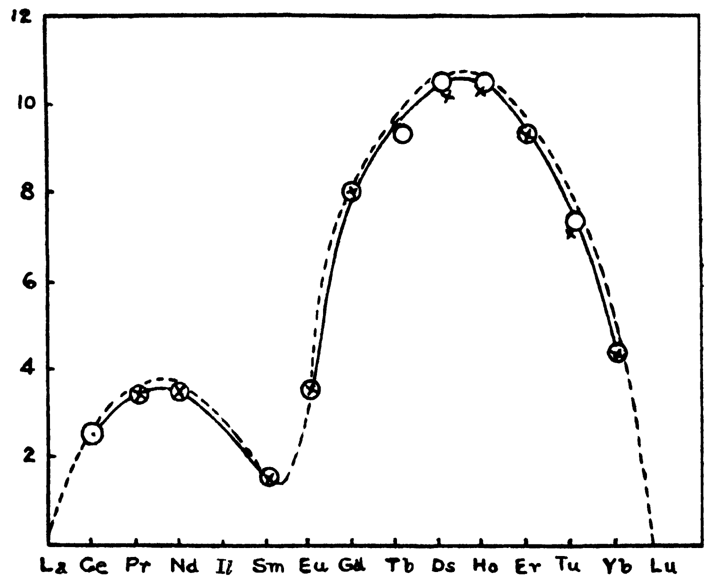
$$P_B = \sqrt{4S(S+1)}$$

according to Bose,[118] Stoner [119] and Van Vleck [120] where $P_B$= Bohr magneton and $S$ is the resultant spin moment. The resultant orbital moment $L$ is rendered more or less completely inoperative due to strong interaction with the neighbouring ions. The actual experimental values and those calculated on the basis of the above formula are set out graphically against the effective atomic number of the first transition series (Fig. 1).

The first half of the series shows quite good agreement ; the last half, on the other hand, reveals an appreciable deviation, and the moments of the ions in this half extend over a short range suggesting that interaction may take place to different extents in different compounds, and is not strong enough to render the effect of the orbital momentum completely ineffective. Thus the experimental results may give an immediate indication of the existence of interaction effects which may leave the spin free but may partially or totally quench the effect of the orbital moment. In order to investigate this point the magnetic moments of Ni, Co, Mn, Cu ions were determined in the author's laboratories.[121] Most of the salts studied were organic, because they could be obtained in a sufficiently pure state. It was observed that both in the case of Mn and Cu ions the experimental and theoretical values calculated according to the Bose-Stoner formula agreed well, thereby indicating the total quenching of the moment. But in the case of the Ni and Co ions the experimental values obtained varied between 2·75 and 3·2 and 4·97 and 5·37 Bohr magnetons respectively, against the theoretical values of 2·83 and 3·87 respectively. If there is no quenching of the orbital moment, according to the Hund formula : $P_B = \sqrt{4S(S+1)+L(L+1)}$ the values should be 5·20 and 4·47 for Co and Ni ions respectively. The experimental results obtained by the authors are in between the two values calculated by the two different formulæ. The results, therefore, indicate partial quenching of the orbital moment and the different ionic moment values with different salts indicate the extent to which the orbital moment is quenched.

In the case of rare earth ions ($Z = 54$ to $Z = 68$), however, the incomplete electron shell which gives rise to paramagnetism is one of the inner shells. It is, therefore, not subject to the strong interactions with the neighbouring atoms as is the unfilled shell of the transition elements. Consequently, the contribution due to the orbital angular momentum to the paramagnetism of the

ions is not annulled and must theoretically be taken into account in the magnetic moment. The older values available for the ionic moments of rare earths, because of their doubtful purity, did not agree well with the theoretical values calculated according to the Hund method. The values obtained during recent years,[122] however, agree closely with the calculated values. This agreement is brought out clearly in Fig. 2 where the experimental and calculated values (according to Hund) have been plotted against the effective atomic number of rare earth ions.




EFFECTIVE MAGNETIC MOMENTS OF RARE EARTH IONS. THE BROKEN CURVE REPRESENTS THE THEORETICAL HUND-VAN VLECK CURVE.

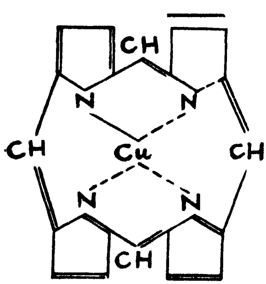
FIG. 2.

The ions of the transition metals of the first series have been found to be paramagnetic, but the complex salts formed by them are diamagnetic, indicating that during the process of co-ordination the unpaired electrons of the outer shells become paired and thus acquire an inert gas configuration, thereby destroying completely the momentum of the ion. Where the inert gas configuration is not acquired the ion exhibits paramagnetism corresponding to the number of unpaired electrons. Thus by investigating the magnetic properties of these complex compounds much valuable information regarding the

nature of various linkages has been brought to light. The theory, however, has several snags and requires a more fundamental physical basis. By such determinations a true complex formation has been distinguished from a more obscure double salt formation. The ionic magnetic moment of Cu in $CuSO_4(NH_3)_4$ and other copper complex salts [47] was found in author's laboratories to be 1·89, exactly the same as that of a Cu ion in an electrovalent salt, against the zero magneton value obtained for tetrakisethylene thiocarbamide copper nitrate.[123] It is therefore to be concluded that in the copper-ammonium complex the various constituents are held together by electrovalent forces, whereas in the other true complex salt the constituents, which go to form the complex, actually share the electrons with the central atom.

Of some general interest during recent years has been the application of this method to the elucidation of the structure of the constituents of blood.

Klemm [124] was the first to investigate the magnetic properties of porphyrin complexes, which form the basis of a number of natural products including blood. The metal complexes of porphyrin derivatives were found to be diamagnetic. If there were a salt-like combination between the metal and porphyrin, the metal complex would be paramagnetic, but because it is diamagnetic, it has to be regarded as a true complex and has been assigned the structure No. 1. On the electronic basis the structure is represented by diagram No. 2. Working



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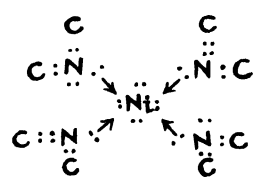

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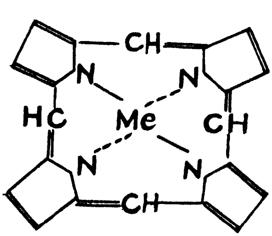

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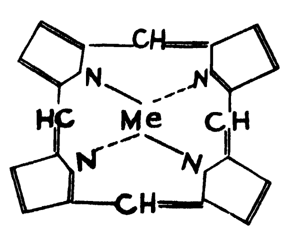


No. 4.

independently, however, Haurowitz [125] found that Ni compounds of porphyrins are paramagnetic and hence concluded that the union of the metal atoms occurs by loss of 2 electrons to the organic group. From the consideration of other properties, such as molecular volume, X-ray spectrum and solubility as well, they have assigned the structure 3 to the metal complexes in preference to 1 and 4. This controversy about the magnetic properties of Ni porphyrin complexes has been closed, since the joint publication of Haurowitz and Klemm,[126] who have recently collaborated and reported that the differences observed by them are not real. They have found the nickel salt of dimethyl mesoporphyrin to be about as diamagnetic as the parent porphyrin itself, and the nickel salt of tetramethyl hematoporphyrin, which was previously reported to be paramagnetic, becomes also diamagnetic on ageing, and have concluded that Ni porphyrins contain no unpaired electrons.

These conclusions have recently been supported from a study of the magnetic properties of the constituents of hemoglobin by Pauling and Coryell.[127] The authors report that globin hemochromogen, dicyanide hemochromogen, nicotine hemochromogen, pyridine hemochromogen and Ni protoporphyrin are diamagnetic and ferriheme and ferroheme are paramagnetic showing magnetic moments of 5·69–5·93 and 5·02–4·83 Bohr magnetons respectively. These magnetic measurements correspond to five unpaired electrons for ferriheme, four for ferroheme and zero for the rest. The presence of unpaired electrons in ferri- and ferrohemes indicates therefore that the iron atom is attached to the four adjacent nitrogen atoms of the porphyrin not by covalent bonds but by ionic bonds. On the other hand the presence of no unpaired electrons in the other four hemochromogens indicates that the 3d orbitals of the ferrous iron atom are involved in the formation of covalent bonds and that the iron atom is accordingly attached by essentially covalent bonds not only to the four porphyrin nitrogen atoms but also to two other atoms giving an octahedral arrangement of six atoms about the iron atom. Continuing their investigations on hemoglobin, oxyhemoglobin and carbon monoxyhemoglobin Pauling and his collaborators [128] have studied the magnetic properties of ferro-hemoglobin and hydroxide, hydrosulphide, fluoride and cyanide of ferrihemoglobin. Both the oxy- and carbon monoxyhemoglobin are found to be diamagnetic and hence to have no unpaired electron indicating that the ferrous iron atom is involved in the formation of six octahedral covalent bonds, four to the porphyrin nitrogen atoms, one to an atom (probably nitrogen) of the globin and one to the carbon monoxide in case of carbonmonoxy and to the oxygen in the case of oxyhemoglobin. The magnetic susceptibility of ferrohemoglobin corresponds to an effective magnetic moment of 5·46 Bohr magneton, of ferrihemoglobin to 5·80, of ferrihemoglobin fluoride to 5·92, of ferrihemoglobin hydroxide

to 4·47 and of ferrihemoglobin hydrosulphide and cyanide to 2·26 and 2·50 respectively. The magneton values for ferrihemoglobin cyanide and hydrosulphide correspond to one unpaired electron per heme, indicating essentially covalent bonds ; for ferrihemoglobin and its fluoride to 5 and for ferro to 4 indicating essentially ionic bonds ; and for the hydroxide to three indicating bonds of an intermediate type.

It would not be out of place to mention here that over ninety years ago Faraday investigated the magnetic properties of dried blood and made a note ‘ Must try fresh blood ’. Had he then determined the susceptibilities of oxygenated and deoxygenated blood he would have found, as Pauling and his collaborators have, a considerable difference and the subsequent researches on blood and hemoglobin would have been considerably influenced by that observation.

Hemmett and Walden [129] as a result of similar magnetic measurements carried out on phenanthroline ferric complexes determined the nature of linkage of the Fe atom with the rest of the phenanthroline molecule. They concluded that because the atomic susceptibility of the Fe atom in the blue complex having the formula $Fe(C_{12}H_8N_2)_3^{+++}$ was found to be $2446 \times 10^{-6}$ practically identical with the value observed with the ferricyanide ion, the Fe atom was co-ordinately linked. In the brown complex $[Fe(C_{12}H_8N_2)_2(H_2O)OH]Cl_2$, however, they suggested that the Fe atoms were so orientated in the molecular grouping that the electronic moments were neutralized and thus accounted for the low atomic susceptibility value observed.

Klemm and his collaborators [130] have employed this method extensively to distinguish between the true and the loose complexes formed by the metals of the transition group of the first series. They could not, however, apply with much success this method to the complexes of the higher members of the transition series, i.e. of Mo, W and Re.[131] In the following Table the experimental and calculated magneton values for some of the complex compounds of the higher transition period are given.

| Name. | Magneton Values. | | |
|---|---|---|---|
| | Determined. | Calculated | |
| | | Hund. | Bose. |
| $Rb(ReCl_4)$ .. | 0·4 | 0·0 | 4·9 |
| $K_3(MoCl_6)$ .. | 3·7 | 0·8 | 3·9 |
| $K_2(ReOCl_5)$ .. | 0·5 | 1·6 | 2·8 |
| $K_4Mo(CN_6)$ .. | 0·0 | 1·6 | 2·8 |

The experimental results do not agree either with the values calculated according to the Bose-Stoner formula or with those calculated according to Hund's method. As the ions of these metals are larger than those of the Fe group, the interaction with the neighbours will be less and will therefore result in an incomplete quenching of the orbital moment, so, the Bose-Stoner formula fails to give satisfactory results. Hund's method fails because the paramagnetism in these metals is due to the outer electrons, whereas the method is applicable to cases like that of the rare earths, where the paramagnetism is due to the incomplete inner shells. Klemm, however, has concluded from his investigations that it would be possible to distinguish between the different linkages in the complex compounds of the higher transition groups, if it is assumed that when the central atom has a smaller volume and a higher electric charge, the interactions of its electronic orbits with neighbouring atoms are greater.

The magnetic properties have been ingeniously employed to decide controversies regarding structures in many complexes. Spacu [132] considered the yellow $\alpha$ form and the black $\beta$ form of ferrous tetrapyridine dithiocyanate to be stereoisomers, whereas Rosenheim [133] postulated the $\beta$ form to be identical with the compound $Fe_3(C_5H_5N)_{10}(SCN)_8$. Asmussen,[134] from a study of the magnetic susceptibility of these compounds showed that $\alpha$ and $\beta$ forms were well-defined compounds and the magnetic susceptibility value of the $\beta$ form was quite different from that of $Fe_3(C_5H_5N)_{10}(SCN)_8$, thus proving Rosenheim's view to be incorrect.

Two varieties of perchromates, red and blue, are known to exist. Schwarz [135] as a result of chemical investigations concluded that Cr in both the varieties is hexavalent. Klemm and Werth [136] determined the magnetic susceptibilities of the two varieties and on comparing the experimental and theoretical values concluded that Cr in the red variety is pentavalent, whereas it is hexavalent in the blue variety. Schwarz,[137] on re-investigating the problem, also arrived at the same conclusion.

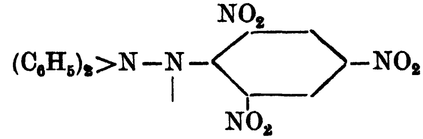
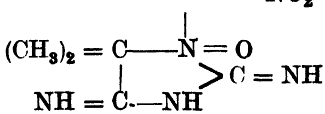
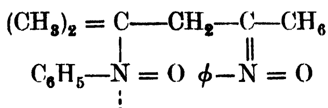
*Study of paramagnetic substances in solution.*—A study of the magnetic properties of solutions of the salts of the transition series has thrown much light on the nature of physical and chemical changes that take place during the process of solution. For some ions in solution, the ionic susceptibility is remarkably constant and the ionic moment both in the dissolved and solid states is the same, as was found by the present author in the case of various Mn salts [138]; for others it varies with the concentration and is modified by the addition of an acid.[139] The striking colour changes of cobalt salt solution from red to blue have drawn much interest. Besides hydration, ionic and double salt formation theories have been employed to explain their behaviour. The study of the magnetic properties of these salts by the workers

at the University Chemical Laboratories, Lahore,[140] confirmed the view that complex ions of the type $CoCl_3$ and $CoCl_4$ are formed.

The formation of complex ions of cobalt in bispyridyl cobaltous chloride has recently been suggested by Sugden and Barkworth [141] in the course of an investigation on the magnetism of cobalt compounds. They found that the stable violet form gave at room temperature $\mu_{eff} = 5{\cdot}34$ Bohr magnetons and that the unstable blue form gave $\mu_{eff} = 4{\cdot}62$. On standing for some days the blue variety changed into the violet one and the magnetic moment value also increased to 5·3 Bohr units. This figure which is higher than 3·87 Bohr magnetons—the value of the electron spin for the $Co^{++}$ ion—appears to be due to the conservation of some orbital momentum of the ion. From these and other theoretical considerations, therefore, they have suggested an ionized structure $(Co_4Py)^{++}(CoCl_4)^{--}$ for the violet form and an unionized structure $(Co_2PyCl_2)$ for the blue form.

*Free and Bi-radicals.*—Magnetic measurements have also yielded valuable information regarding the existence of 'free radicals', which have been defined as substances the molecules of which contain an odd number of electrons. In molecules containing an odd number of electrons, as in ions, there is necessarily a resultant spin moment which will give rise to paramagnetism. If this moment is due to spin only (any orbital moment being quenched) theoretically the value of $\mu_B$ calculated from $2{\cdot}84\sqrt{\chi_M(T-\theta)}$ would be 1·73 units. This has been shown to be valid for NO (15 electrons), $NO_2$ (23), $ClO_2$ (33) and $Clo_3$(41).[142] The feasibility of this principle has been abundantly proved recently by Sugden and Müller. Compounds, such as triphenyl-methyl having the molecule of the free radical form $(C_6H_5)_3C$ containing trivalent carbon, have one unpaired electron. Therefore a completely dissociated $[(C_6H_5)_3C]_2$ molecule should have a magnetic moment of 1·73 Bohr magneton. Sugden [143] studied a number of such compounds (No. 1–5) and found that they were strongly paramagnetic but with an effective magnetic moment, rather less than the calculated one. This discrepancy was attributed to the presence of diamagnetic undissociated molecules. In contrast to these in compounds No. 7–11 studied by Müller and his collaborators [144] the experimental value agrees with the theoretical one.

| | *Substance.* | $\mu_B$ *observed.* |
|---|---|---|
| 1. | α-naphthyldiphenyl methyl .. .. | 1·15 |
| 2. | $(p\text{-}NO_2 . C_6H_4)_3C$ .. .. .. | 1·36 |
| 3. | Benzoquinone potassium $(C_6H_5)_2 = \overset{\vert}{C}-OK$ .. | 1·45 |
| 4. | Phenyl-*p*-diphenylyl potassium .. .. | 1·58 |

| | Substance. | $\mu_B$ observed. |
|---|---|---|
| 5. | $Ph_2N . N . C_6H_2(NO_2)_3$ .. .. .. | 1·61 |
| 6. | $(C_6H_5-C_6H_4)_3 \equiv C^-$ .. .. .. | 1·75 |
| 7. | Di-*p*-anisyl-N-oxyl $(CH_3O-C_6H_4)_2 = N = O$ .. | 1·71 |
| 8. | α-α-diphenyl-β-trinitrophenylhydracyl  .. | 1·74 |
| 9. |  .. .. | 1·76 |
| 10. |  .. .. | 1·76 |
| 11. | Pentaphenyl-cyclopentadienyl .. .. | 1·72 |

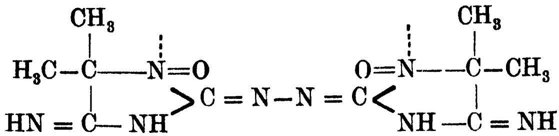
The corresponding dimeric molecules of these free radicals are, however, diamagnetic. The magnetic method, therefore, may be conveniently used to determine the degree of dissociation of such compounds. There are many other usual methods such as depression of the freezing point, elevation of the boiling point and the more accurate optical method recently developed by Ziegler and Ewald.[145] But these methods cannot be employed with any great degree of accuracy to substances like $C_2(C_6H_5)_6$, which decompose into free radicals, or such as are solid at ordinary temperatures. Müller determined the degree of dissociation of $C_2(C_6H_5)_6$ by the magnetic method, and the results were in very good agreement with those obtained by the optical method. Similarly the degree of dissociation of hexa-aryl substituted ethane has been determined by Müller.[146] The degree of dissociation (2·71) determined by the magnetic method was found to be in close agreement with the value 2·80 obtained by the optical method. Recently Farquharson[142] has determined the degree of dissociation of $Cl_2O_6$ both in the liquid and the solid states by magnetic measurements.

This method has its limitations. It can be used conveniently for those compounds which can be obtained in a pure state and have a high dissociation constant.

Furthermore, it would be possible with the help of magnetic measurements to prove the existence of bi-radicals, i.e. such substances as have two free linkages due to two unlinked electrons

which do not interact with each other. The spins of the free electrons should not compensate each other, and at room temperature ought to have an effective magnetie moment of 1·73 for each half of the molecule.

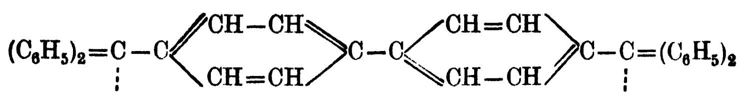
Many compounds, which on account of their colour and other properties have been supposed to be bi-radicals, have been magnetically examined, but till now only two such bi-radicals have been shown to be capable of existence. Porphyrindine is a bi-radical containing two unsaturated N atoms. Its experimental susceptibility value agrees well with the theoretical one.



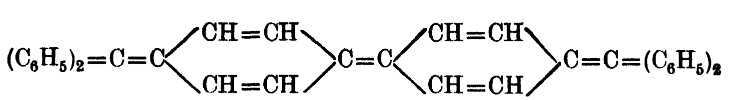
Porphyrindine.

Müller [147] found that *m-m'*-diphenylene-bisdiphenyl-methyl in the solid state and in solution at room temperature existed as an associated diamagnetic double molecule. At high temperatures, however, the deepening of the colour and the paramagnetism proved the presence of a bi-radical.

On account of the strong colour developed and of great reacting power, it had been the tendency to formulate such compounds as bi-radicals. A hydrocarbon, discovered by Tschitschibabin,[148] which exhibited great attraction for oxygen and was deeply coloured, was assigned formula I in preference to *p*-quinonoid formula II.



I.



II.

The magnetic investigation by Müller [149] showed that paramagnetism corresponding to I was absent. Similarly Müller had shown from the magnetic measurement of triphenyl α-naphthyl-quinodimethane that the quinonoid structure should be preferred to the structure assigned by Allard.[150] Enderlin [151] from magnetic determinations showed that rubene derivatives do not exist as bi-radicals under ordinary conditions. They also showed that in a dissociable oxide of tetraphenyl rubene oxygen though easily removable does not exhibit paramagnetism.

Müller and Sugden have studied a number of compounds which are supposed to be bi-radicals. Müller, however, concluded from magnetic measurements that if the bi-radicals do exist, they are no more than 2%. If the method for magnetic measurements can be developed so that $\chi$ of the solution is obtained with an accuracy of 1 per 1,000, it would be possible to prove definitely the absence or existence of bi-radicals.

Sugden [152] recently observed that thiobenzophenone, which from its chemical and physical characteristics has been supposed to be a bi-radical, is diamagnetic. Therefore, he suggested that probably the spins of the two free electrons are opposed to each other resulting in the destruction of paramagnetism and concluded that the magnetic test is not a decisive one for bi-radicals. This view is, however, open to the objection that the word bi-radical has recently been exclusively applied to those molecules which have two free valencies independent of one another.

Since it has been established that 'odd' molecules are invariably paramagnetic, the magnetic method has been used to elucidate the electronic structure of compounds and also to decide in other cases, whether those compounds should be represented by a simple or a double formula.

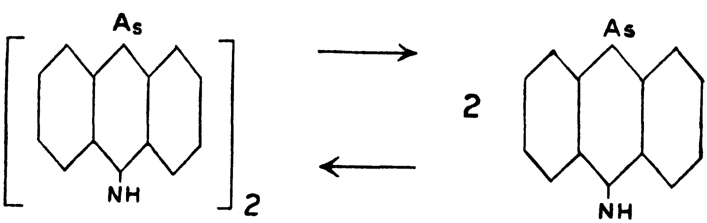
Lowry [153] assumed the existence of single electron linkage in $Me_2TeX_2$, where X is Cl, Br or $NO_3$. These compounds were, however, found to be diamagnetic. If these compounds do contain single electron bonds, then there should be a paramagnetic effect due to unpaired electrons. Actually this effect would be masked by the diamagnetic effect of the rest of the molecule. Since, however, diamagnetism is independent of temperature and paramagnetism is affected by it, any masked paramagnetic effect would be shown by a variation of $\chi$ with the temperature. Investigations carried out in the author's laboratories [154] showed that the values of $\chi$ of these compounds are independent of temperature. Further assuming all the bonds to be electron pairs, the calculated values according to Pascal have been shown by the author to agree well with the observed values. Therefore, it has been concluded that there is no evidence of the existence of single electron bonds in such compounds. Similarly Mulliken [155] had to suggest another electron configuration for $B_2H_6$ to account for its diamagnetic character. By a similar investigation Elliot [156] elucidated the structure of triple salts, e.g. $Cs_2AgAuCl_6$ and $Cs_2AuAuCl_6$.

It has been debated whether the salts of hyposulphurous acid should be represented as $RSO_2$ or $R_2S_2O_4$, where R is the metallic radical. Meyer [157] from the study of various physical properties concluded that the sodium salt should be represented as $Na_2S_2O_4$. If the formula is $NaSO_2$, sodium hyposulphite would be paramagnetic, whereas the double formula $Na_2S_2O_4$ represents a diamagnetic molecule. Recent experiments of Klemm [158]

showed that this substance is diamagnetic and thus gave a decision in favour of the structure :

$$\begin{array}{c} \mathrm{O} \\ \| \\ \mathrm{Na{-}S = O} \\ \mathrm{Na{-}S = O} \\ \| \\ \mathrm{O} \end{array}$$

Sugden[159] from similar investigations represented hypophosphorous acid as $H_4P_2O_6$ ; Klemm[160] represented a compound formed by the interaction of alkali metal and $B_2F_6$ as $K_2B_2F_6$ and not $KBF_3$ ; Elliot[161] represented the double salt ammonium hexabromo hypoantimoniate as $(NH_4)_4Sb^{\cdots}Sb^{\cdots\cdots}Br_{12}$ containing tri and pentavalent Sb and not as $(NH_4)_2SbBr_6$ with quadrivalent Sb in which case it would have been paramagnetic. Similarly Sugden[152] found 10 : 10′-bis 5 : 10-dihydrophenarsazine to be diamagnetic and assigned to it the formula I in spite of its colour and reactivity which may suggest formula II.




## 6. Polymerization.

Valuable information on the question of polymerization can also be obtained by the magnetic methods. Not long ago these methods were restricted in their application to paramagnetic molecules only, which on polymerization became diamagnetic. More recently it has been possible to extend these methods to include the treatment of diamagnetic molecules which polymerize. Where $n$ molecules would polymerize to form the polymer $nA$, the general expression for the molecular susceptibility of the polymer will be

$$\chi_A = n\chi_A + (n-1)\lambda$$

where $\chi_A$ is molecular susceptibility of the molecule $A$ and $\lambda$ is the constitutive constant arising from the new chemical bond, and the mass susceptibility of $nA$ would be

$$\frac{n\chi_A + (n-1)\lambda}{nM_A}$$

where $M_A$ is the molecular weight of the simple molecule $A$. In this expression $\chi_A$, $M_A$ and $\lambda$ are constant and the curve for the change in the mass susceptibility with the number of simple molecules in the complex will, therefore, be a hyperbola. $\lambda$ is given by Pascal's results so that by measuring the mass susceptibility, it should be possible to calculate $n$.

Farquharson [162] has studied the polymerization of dimethyl butadiene and cyclopentadiene and confirmed that polymerization gives rise to a change in diamagnetic susceptibility and that, as polymerization proceeds, the mass susceptibility follows a curve, which in the normal case is a hyperbola. Change in mass susceptibility on polymerization was also observed by the present author [163] in anthracene, acetone, benzaldehyde, furfurol and acetyl cyanide.

Farquharson [164] has employed the magnetic data of polyoxymethylenes, the polymerized products of oxymethylene diacetates to determine the -$CH_2O$-groups in $\alpha$ and $\beta$ polyoxymethylenes.

These magnetic measurements of polymerized compounds would help us to follow the course of polymerization and in certain cases may be useful in calculating the degree of polymerization.

## 7. Magnetic Properties in relation to Phase Equilibrium.

Magnetic susceptibility measurements have been frequently used in the study of phase rule equilibria, because, as a result of extensive study of the magnetic properties of various systems, certain rules which provide very useful information regarding structure, formation of intermediate compounds, etc. have been formulated. For example, it is concluded that in the case of solid solutions the susceptibility-concentration curve is a curved line, in the case of mechanical mixture of the constituents the curve is a straight line, whilst the appearance of a new phase indicating the formation of a compound brings about an abrupt change in the slope of the curve. These generalizations have been used by numerous investigators in the study of alloys. Svensson [165] thus studied the Pd-H system and from the analogy of the susceptibility-concentration curve with that of Pd-Ag system concluded that in this system several PdH-Pd alloys are formed. From similar investigations Stephens and Evans [166] have recently shown that the formation of a compound $Ag_8Sb$ at 73% is indicated in the system Ag-Sb, but no such compound formation is indicated in the Ag-Bi, Ag-Pb systems. Fallot [167] has studied the magnetic properties of several alloys of Fe with Al, Si, Cr, V, Au and Sn. He found singular points in the curves, corresponding to modifications or 'superstructures' which were found by X-ray studies, and along with these he found other

singular points indicating the presence of other 'superstructures' which had not been detected by X-rays, either because the concentration of the foreign atoms was too low or because their atomic masses were too near to that of Fe. He has thus suggested the study of magnetic properties of alloys as an exceedingly sensitive means for detecting these superstructures.

It is remarkable that, although the alloys of almost every metal have been so extensively investigated, the systematic survey of the magnetic properties of amalgams has not attracted attention till recently. The present writer [168] found that dilute amalgams of copper are merely mechanical mixtures of the two metals in which the value of the magnetic susceptibility varies from that of pure mercury to that of pure copper. Recently Bates and Tai [169] have studied the magnetic properties of a series of amalgams of various concentrations of Mn, Bi, Cr and Cu and found that with the exception of copper all the metals which are diamagnetic in the solid state become paramagnetic in dilute amalgams. The paramagnetism of the metals in amalgams may be suggested to be due to their being in the atomic state, but to establish it a study of their thermomagnetic behaviour would be desirable.

A rather interesting development in this field has been the study of magnetic moments of elements when alloyed with different metals. Gustafsson [170] has recently determined the atomic moment of Mn when alloyed with Cu, Ag and Au and obtained in infinitely dilute solutions a value of 4·8 Bohr magneton in Cu, 5·5 in Ag and 5·4 in Au. The low value for Cu solution is attributed to the small atomic volume of copper. Fallot has employed this method to determine the atomic moment of Fe when alloyed with Pt, Si, Al, Cr, Au and Sn and found that in general an average moment of 11·00 or less occurs in series with elements of lower atomic number than Fe, while values of 11·00 or more are found in the series of alloys with elements of higher atomic number. It has been shown by Stoner [171] that many of the salient facts about the variations of atomic moment in ferromagnetic alloys are readily explained on the basis of a collective electron treatment of ferromagnetism, which is being actively developed by Slater,[173] Mott,[172] Stoner [174] and others.

Not only in alloys, but also in compounds the magnetic susceptibility has been studied in relation to phase rule equilibria. The present author [175] examined the magnetic properties of solid solutions of $KMnO_4$,-$KClO_4$, KCl-NaCl, KBr-KCl and KBr-NaBr and found that in the system $KClO_4-KMnO_4$ the susceptibility-concentration curve is a straight line, while the other systems yield curved graphs. The abrupt change of slope in the susceptibility-concentration curve has been recently made use of by Haraldsen and his collaborators, particularly in the study of such systems in which one compound is diamagnetic, while another is para- or ferromagnetic. Haraldsen [176] found that the

addition of S to CoS does not bring about any change in the magnetic susceptibility until the composition $CoS_{1\cdot18}$ is attained. At this point, saturation of the mixed crystal series is reached and a new strongly paramagnetic phase ($CoS_2$) appears, forming a two-phase system between the composition limits $CoS_{1\cdot18}$ $CoS_2$. Similar observations have been made by Haraldsen and Neuber [177] in the case of the system Cr-S in which the considerable increase in magnetism takes place at a concentration corresponding to $CrS_{1\cdot175}$. This behaviour of Co and Cr is analogous to that of the Fe pyrites, which shows a maximum in magnetization at $FeS_{1\cdot12}$.

## 8. Influence of the Magnetic Field on Homogeneous and Heterogeneous Equilibria.

Although not much attention has been bestowed upon the study of the influence of the magnetic field on the rate of crystallization, electrolysis, conductivity of gases, coefficient of viscosity, etc. during recent years, investigation of these subjects is sure to lead to important developments in magneto-chemistry. Of particular interest is the work of Steacie and Stevens,[178] who observed that a field of 5,000 gauss had no effect on the linear crystallization of $Na_2S_2O_8 . 5H_2O$, whereas a slightly increased rate was observed with $NiSO_4 . 6H_2O$. Senftleben and his fellow-workers [179] have reported a definite diminution of the thermal conductivity of oxygen in the magnetic field. Because of the close relationship between diffusion and thermal conductivity Engelhardt and Sack [180] investigated the effect of the magnetic field on the coefficient of viscosity of oxygen and observed definite diminution of it. Similar results have been reported recently by Trautz and Fröschel.[181] Raha and Chatterjee [182] have extended these investigations to liquids and found that liquids with long chain aliphatic molecules, i.e. acetone and propyl alcohol show diminution, liquids of the aromatic class, i.e. nitrobenzene, toluene and isoamyl alcohol show increase, and carbon tetrachloride and cerium nitrate solutions show no change in the magnetic field.

The magnetic field influences also the course of chemical reaction. The subject has been critically examined by the author in the treatise on magneto-chemistry [183] and from the data then available the conclusion was drawn that a reaction would be accelerated, retarded, or remain unaffected according to whether the sum of the molecular susceptibilities of the products is more than, less than or equal to the sum of the molecular susceptibilities of the initial substances.

The influence of the magnetic field on the phenomenon of adsorption has also been investigated in the author's laboratories.[184] It has been observed that the difference in adsorption inside and outside the fields depends on the field strength

applied.[185] Investigations of this type have already provided valuable information regarding the mechanism of adsorption.

## 9. Catalysis and Magnetic Properties.

It has been observed that a study of the magnetic properties of the catalysts may yield valuable clues to the theory of catalysts. Hedvall, Hedin and Persson,[186] while studying the reaction of $2N_2O \rightarrow 2N_2 + O_2$ using Ni as a catalyst, observed that the rate of decomposition is suddenly increased above the Curie point, although the X-ray investigations by Nunzio [187] do not indicate any difference between the lattice structure of Ni above and below the Curie point. Experiments repeated with samples having different Curie points also indicated an increase in the reaction velocity above the corresponding temperature.

An extension of the work by Hedvall and others [188] has shown that the hydrogenation of carbon monoxide and acetylene by Ni and the formation of $CO_2$ from CO by Heusler's alloys is much accelerated at the Curie points. The changes involved in the catalysts are also partly structural.

The fact that catalytic activity may have some relation to the magnetic behaviour, was also confirmed in an extended investigation by Taylor and Diamond,[189] who found that the spin isomerization of hydrogen at low temperatures is much more catalyzed by a paramagnetic surface than by a diamagnetic one. Even in cases where the bulk of the material is diamagnetic, the catalytic activity is attributed by them to a paramagnetic surface. This idea, though rather far fetched, would certainly require further investigation.

## 10. Magneto-optical Analysis.

Allison and Murphy's magneto-optical method [190] of chemical analysis, which depends on the investigation of the time-lag of the Faraday effect behind the magnetic field as a function of the wave-length of the light used, has been the subject of much controversy during recent years. Recently, Slack [191] has reported that, although minima were observed, yet he regarded them as a result of physiological and psychological effects. Furthermore, with Peoples,[192] he reports that attempts to reproduce time-lag measurements and chemical analyses have failed. MacPherson [193] also finds himself in substantial agreement with Slack and others and is unable to confirm sharp minima characteristic of the substances under investigation. More evidence of similar nature comes from Jepperson and Bell.[194] On the other hand Hughes and Goslin [195] seem to have refuted the criticism by demonstrating the reality and reproducibility of the minima photographically. They have used this method for detecting the localization of metals in organs and tissues of

animals. Furthermore, Wissink and Woodrow [196] have such confidence in the method that they use it to detect vitamin A, to the presence of which they attribute the characteristic minimum given by many animal and vegetable products.

## 11. Photomagnetic Effect.

It is desirable in this survey to include also an account of what may be termed the photomagnetic phenomenon. Light brings about a number of physical, physico-chemical or chemical changes ; the magnetic study of these effects should be of considerable value in explaining the nature of the changes involved by light. During the last few years attention has been paid to the magnetic study of photo-phenomena to justify the treatment of the results under a separate head.

Heaps [197] investigated first the magnetic properties of illuminated silver chloride and selenium and showed that no change in the magnetic susceptibility takes place on solarization. Some preliminary experiments on the magnetic behaviour of silver halides have been carried out in the author's laboratories [198] and it has been shown that a change in magnetic susceptibility takes place when these substances are exposed to sunlight for extended periods. Change in the magnetic susceptibility in the case of the iodide can quantitatively be accounted for satisfactorily, if it is supposed that the halide decomposes into the metal and the halogen. The whole subject is at present under investigation.

Another of the vexed problems of photo-chemistry is the phenomenon of phototropy. Phototropic substances are known to undergo a change in colour on exposure to light of a suitable frequency. This change in colour is completely or partially reversible when the exposed substances are kept in the dark for sufficiently long time, heated or recrystallized. Generally this phenomenon is not accompanied by any change in physical properties like melting points, crystal structure, etc. Measurements of the magnetic susceptibilities of phototropic anils, hydrazones, semi-carbazide and anthracene have been carried out before and after exposing them to sunlight in the author's laboratories.[92] The value of the exposed and unexposed samples was found to be the same, except in the case of anthracene [168] where the change is due to photo-polymerization.

From the rate of colour development Padoa [199] suggested the mechanism :

$$A_2 \underset{\text{Dark}}{\overset{\text{Light}}{\rightleftarrows}} 2A$$

for benzaldehyde-phenylhydrazone and salicylidene $\beta$-naphthylamine. But it seems more reasonable, as was pointed out by

Senier and Shepheard,[200] to assume that light causes a change in aggregation only and that this change is reversible. If that is so, no change in the magnetic susceptibility may be expected, which is in accord with the experimental facts.

Emberson and Dufford [201] have also looked for a photo-magnetic effect in photovoltaic substances and shown that no change in magnetic susceptibility takes place on exposure to light. They suggested that either the magnetic susceptibility is not dependent on the number of free electrons or more probably the photovoltaic effect does not involve the liberation of free electrons.

There are, however, a number of cases where exposure to light has definitely been shown to bring about a change in the magnetic susceptibility, the effect being more or less explicable on theoretical grounds. Bhuyan [202] observed that halogen molecules show an increase in magnetic susceptibility on exposure to light. Although on theoretical grounds the halogens may be expected to be adiabatically dissociated into atoms in the $^2P_{3/2}$ and $^2P_{1/2}$ states, both of which ought to be paramagnetic, the increase in diamagnetic susceptibility observed is probably due to the large number of excited molecules. This is borne out by the observation that the change is completely reversed on taking away the light source.

Bose and Raha [203] have recently extended their earlier work on photomagnetism and found that a positive effect is shown by solutions of vanadium ions in different valency states and by crystals of $NiSO_4 . 7H_2O$. This effect decreases in the order of $Ni^{\cdot\cdot}$, $Cr^{\cdot\cdot\cdot}$ and $Co^{\cdot\cdot}$ and is absent in the solutions of Cr and Ni in hydrochloric acid.

In order to explain their observations Bose and Raha have assumed a sort of loose chemical combination between the molecules of the solvent and the paramagnetic ion, which breaks down on exposure to light. They have concluded that, if the orbital moment is equally quenched in the initial or the final states as in the case of $Cr^{\cdot\cdot\cdot}$ and $Ni^{\cdot\cdot}$ in HCl, no photo-magnetic effect would be observed. The positive effect in the other substances should be attributed to the quenching of the orbital moment. A further study of this effect is bound to be of considerable interest at least from the point of view of the much vexed question of the theory of solutions.

Under the head of photo-magnetic phenomena, the phenomenon of extinction of fluorescence under the action of the magnetic field may also be included, which was observed and studied by Genard [204] in a series of papers. It has been shown that fluorescence excited in the vapours of $I_2$, $S_2$, $Se_2$ and $Te_2$ by a suitable frequency is considerably and sometimes entirely removed by a magnetic field. On close analysis it has been shown that terms of the same series and quite often the components of the same multiplet are differently affected ; the

fluorescence of some lines is reduced, and of others is enhanced. In the case of iodine, Genard has concluded that probably an electronic level exists between $^1\Sigma_{g+}$ and $^3\pi_{0\mu}$. This is in agreement with Van Vleck's theory. Zeeman effect alone cannot explain this phenomenon. I hope I have succeeded in showing some of the interesting and fascinating features of this subject.

In concluding this survey, I cannot help hoping that this historic meeting will help us in forging new bonds of personal magnetism which will lead to further advances in Physics and Chemistry and to the cementing of the relations between the East and the West and the old and the new worlds.

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# SECTION OF GEOLOGY

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## THE STRUCTURE OF THE HIMALAYAS AND OF THE NORTH INDIAN FORELAND

CONTENTS.



### I. TECTONIC FEATURES OF THE FORELAND.

Geological work carried out during the last few years has thrown much light on the structure of North India, a region of extraordinary tectonic interest, as much on account of the magnitude and intensity of the crustal deformations, involving the upwarp of the Himalayan chain and the formation at its foot of a deep parallel depression, as on the extreme youth of these world-transforming events. The region of North India resolves itself tectonically into two broad belts, the plicated geosyncline of the Himalayas; and the northern edge of the Indian peninsular massif, that has acted as the *foreland* and in the process sagged under the strain of the folding of the northern orogen. This belt of the passive and inflexible block of Gondwanaland, which bears clear marks of its complicated reactions to the great tectonic and orogenic displacements of Central Asia during late Tertiary and Quaternary times, has

received less attention, but is hardly of less interest, from the point of view of structural geology, than the more prominent and striking Himalayan belt.

In this address I propose to deal with the geological structure of (1) the North Indian foreland, and (2) of those parts of the Himalayas that have been investigated in some detail by geologists in India during the last two decades or so, and of their inter-relation in a common tectonic plan.

The chief units of the foreland concerned in this investigation are :—

(1) The Rajputana plateau, prolonged northwards into the 'Punjab wedge' of the Gondwana foreland; it is traversed by the Aravalli range of Algonkian uplift, its tectonic strike being transverse to the main Himalayan trend. (A. M. Heron.)

(2) The Potwar trough, the north-western branch of the Indo-Gangetic depression, whose geosynclinal structure is well exposed, revealing a sequence which epitomises the whole Tertiary history of North India (E. S. Pinfold, D. N. Wadia, R. V. Anderson, G. deP. Cotter.)

(3) The Gangetic trough, a synclinorial depression between Peninsular India and the southern front of the Himalayas, 1,200 miles long and 250 miles broad, of post-Tertiary formation, and filled up by Pleistocene alluviation. (R. D. Oldham, S. G. Burrard, E. A. Glennie.)

(4) The Assam plateau and Assam valley; the plateau is a tongue of the Peninsular mainland; between it and the Himalayan foot is the Brahmaputra valley, a 'ramp valley', filled up by recent alluvium. (C. S. Fox, P. Evans.)

But few parts of the Himalayas have been examined in detail so far for their structural plan. The important work of Medlicott, Middlemiss and Hayden referred mainly to the unravelling of the stratigraphic succession. Of late years the following areas have received considerable attention as regards their geotectonics. Investigation is still proceeding in all these areas and the views here expressed are by no means final but more or less tentative; they may have to be modified in some substantial detail or other by further work :—

(5) The Hazara-Kashmir syntaxis, showing the reaction of the north-western Himalaya against the Punjab wedge. (D. N. Wadia.)

(6) Areas showing over-thrusts and nappe structures in the Simla Himalaya. (G. E. Pilgrim, W. D. West.)

(7) The superposed nappes of Garhwal Himalaya. (J. B. Auden.)

(8) The structure of the Eastern Himalaya, Mount Everest region. (A. M. Heron, L. R. Wager.)

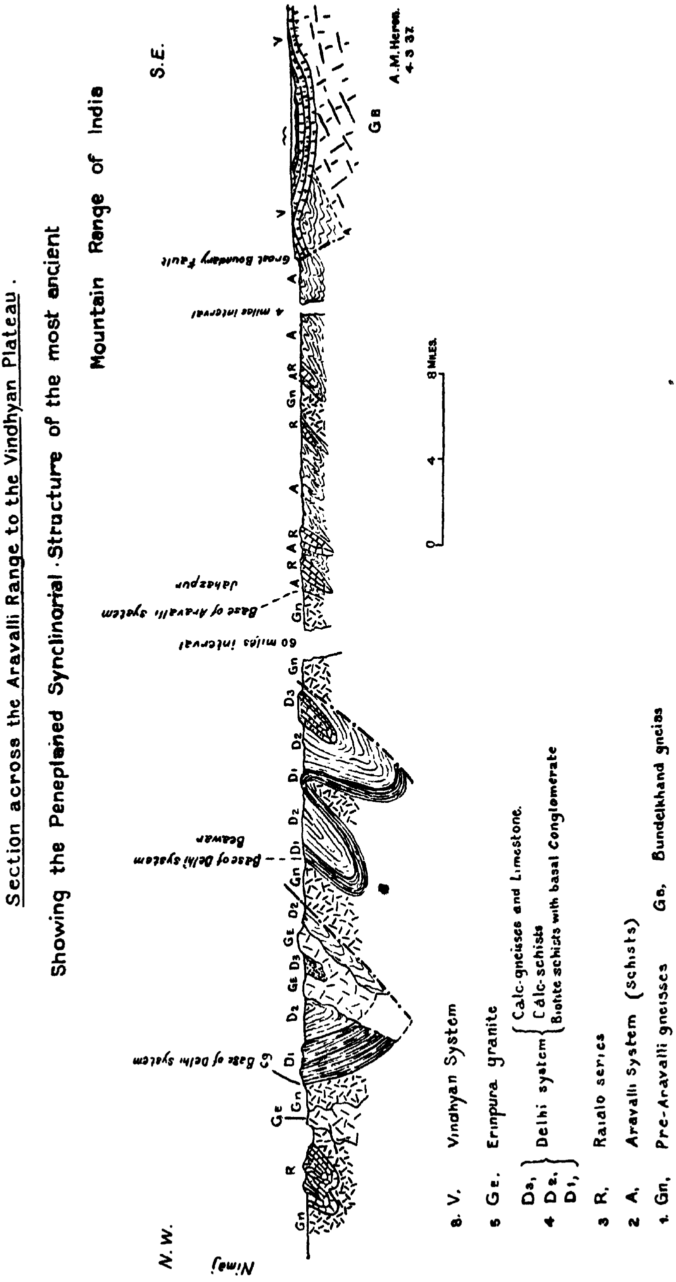
(9) The syntaxial bend of the Assam Himalaya to a reversed direction against the granitic plateau of Assam.

### 1. *Rajputana and the Aravalli range.*

Detailed field work in Rajputana[5,6] has thrown light on the structure and stratigraphy of the northern sector of the Archæan block of Peninsular India, the Punjab prolongation of which has played a most important part (the 'Punjab wedge') in determining the orogenic trend-lines of north-west India and, according to Mushketov and other Russian geologists, of the Pamir and Ferghana region also. Its most important tectonic feature is the now peneplaned Aravalli range of Archæan and pre-Cambrian rocks, perhaps the oldest true mountain chain in the world, representing a synclinorium of post-Torridonian uplift with a pronounced N.N.E.-S.S.W. strike, in the main transverse to all the later tectonic trends of Northern India. The constituent rocks of the Aravalli synclinorium are Archæan fundamental gneisses, superposed by 3 great systems of Archæan sediments, separated by important unconformities. The crest of this greatly compressed basin-fold dives down underneath the alluvium at Delhi after a N.N.E. course of five hundred miles from Gujarat. It is constituted of the oldest of the post-Archæan systems—the Delhi system—which again exhibits unconformable and fault relations to the next succeeding Vindhyan system, of uncertain Cambrian age. The south-eastern flank of the Aravallis is delimited by a boundary fault against a massive outcrop of the Vindhyans, the edge of which is steeply corrugated and profoundly affected by the last Aravallian uplift. Heron believes the main crust-folding movement of Rajputana to be of Purana, if not later age, and to have infolded the Delhis into the Archæans. The Algonkian (Purana) era in Rajputana was one of igneous and orogenic activity, localized and more or less confined to the Aravalli region, so that outside this orogenic belt the rocks, even though so ancient, are unmetamorphosed.

A north-westerly branch of the Aravallis, striking off from Delhi and extending to the Salt Range, underneath the alluvium, is revealed by geodetic observations; another series of positive gravity anomalies, indicating an upwarp, suggests a northward continuation of the range from Delhi to Saharanpur at the edge of the Simla Himalaya.

The last uplift of the Aravallis must be of post-Vindhyan date (? Caledonian), though it is probable that they may have been rejuvenated at some later periods, before the great Permo-Carboniferous glaciation, during which the Aravallis were a centre of giant glaciers radiating to distant parts of India. No orogenic movement has affected this part of the Indian foreland since the last Aravallian uplift, and subsequent to that the Indian Peninsula has played a passive rôle all through the



Section across the Aravalli Range to the Vindhyan Plateau.
Showing the Peneplaned Synclinorial Structure of the most ancient Mountain Range of India
N.W.
S.E.
Nimaj
Base of Delhi system
Base of Delhi system
Beawar
60 miles interval
Base of Aravalli system
Jahazpur
4 miles interval
Great Boundary Fault
Gn R Ge Gn Cg D1 D2 Ge D3 Ge D2 Gn D1 D2 D1 D2 D3 Gn
Gn A R A R A A R Gn AR A A V V Gb
0 4 8 MILES
A.M.Heron. 4.3.37
8. V, Vindhyan System
5 Ge, Erinpura granite
4 D3, D2, D1, Delhi system: Calc-gneisses and Limestone. Calc-schists. Biotite schists with basal Conglomerate
3 R, Raialo series
2 A, Aravalli System (Schists)
1 Gn, Pre-Aravalli gneisses Gb, Bundelkhand gneiss

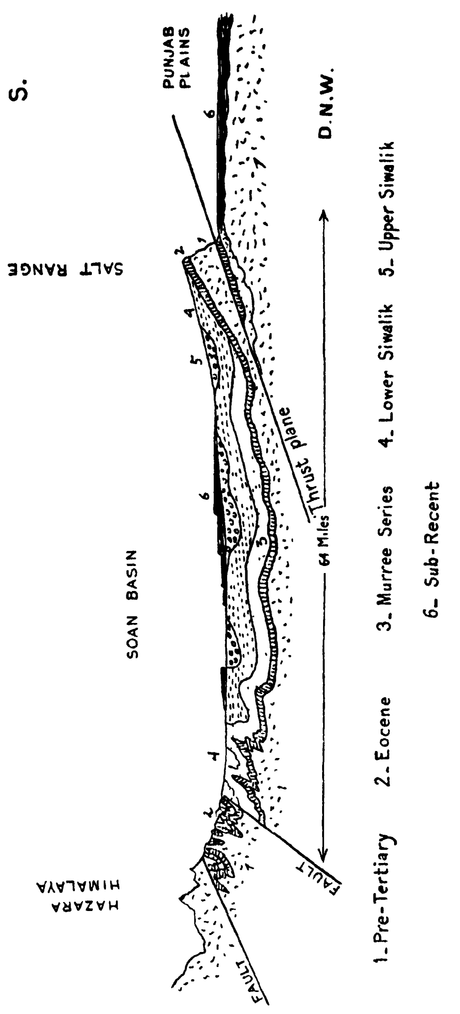

FIG. 1.

vista of geological history. The only tectonic movements of this region are of the nature of block-faulting and tensional cracks which, however, have affected the Peninsula on a considerable scale during the Hercynian period and produced, besides a number of long linear fractures, a series of fault-troughs—the Gondwana coal-bearing basins of east India.

## 2. *The Potwar Geosyncline.*

The Punjab foreland, just north of the Salt Range and the area last described, is a deep structural trough. 25,000 feet of Tertiary sediments, from the Eocene to Pleistocene in a conformable sequence, is folded into this synclinal basin lying between the Salt Range and the skirt of the Hazara Himalaya. This rock sequence epitomises the whole Tertiary geology of North-western India.[8, 9, 11, 13] The syncline is 70 miles broad and 150 miles long, tapering out east of the Jhelum into the Siwalik foot-hill zone. The structural axes in the Potwar region run generally E.N.E.-W.S.W. The floor of the basin is the deeply eroded, peneplaned extension of the Rajputana foreland. Some isolated exposures of its rocks are met with south of the Salt Range in a chain of hillocks near Sargodha, with a north-westerly strike. The Potwar basin is regarded as a north-westerly ramification of the vast Indo-Gangetic trough, into which it merges to the south-east. The simple structure of the main part of the fold is replaced at its northern margin by a series of much plicated isoclines and recumbent folds as the mountain-foot is approached (Kala Chitta and Margala hills). Here the strata are tightly packed and faulted, the dominant structure being isoclinal, all the folds being overthrust from north to south. To the south of this is a broad belt of open folds, with their axial planes dipping north and separated by strike-faults hading in the same direction. The parallel lines of reversed faults (boundary-faults) of the Himalaya become recognisable east of the Jhelum ; trans-Jhelum they disappear in anticlines. The southern rim of the Potwar basin is the gentle dip-slope face of the Salt Range with a highly sinuous alignment. In the opposite southern scarp face of these mountains, rising steeply above the flat alluvial plains of the Punjab, are laid bare the Palæozoic and Mesozoic rocks that were deposited on the foreland during prolonged but shallow marine transgressions of the old (pre-Tethyan) Himalayan sea during the Dravidian era and of the Tethys during the Aryan era (the long marine period of the Himalayas from the Uralian to the Eocene). Both these systems of deposits were of the epicontinental type. The southern edge of the Potwar plateau, as revealed in the Salt Range escarpment, is of great interest in the tectonics of Northern India. It reveals tectonic movement of a momentous nature, the whole range having slid forward bodily along a plane of

thrust that must have offered such resistance as to impart a highly tortuous base-line to this line of abrupt-faced mountains.[18]




SECTION ACROSS THE POTWAR GEOSYNCLINE

FIG. 2.

Structurally it is a disrupted monocline, its severed upper limb overriding and completely obliterating the southern limb. The Salt Range has lately been studied in detail by E. R. Gee, who postulates a thrust-plane, along which the bottom rocks of the

Potwar basin have moved towards the south, and partly to the east, involving a horizontal thrust of nearly 20 miles.* Its further movement was arrested by the resistance of the Sargodha ridge of the foreland referred to above, which lies buried at no great depth under the alluvium. The great dent in the alignment of the mountain at the Indus marks the site of this obstruction. Tectonic movements in the Salt Range continued into the Pleistocene in sympathy with the later Himalayan orogenic operations.

Between the isoclinally folded Kala Chitta hills and the monoclinally thrust-faulted Salt Range, the Potwar depression lies without notable compression or faulting. To the south-east a portion of the fold is covered up by the Punjab alluvium, another portion merging into the Siwalik belt of Jammu and Simla. The basin structure so pronounced in Potwar gradually flattens and widens into the broad shallow Indo-Gangetic trough.

### 3. *The Indo-Gangetic Trough.*

The gentle down-warp structure of this region is now generally accepted—a foredeep in front of the crustal buckling of the Himalaya, and produced as a concomitant of that uplift.[4] There is much structural evidence for this belief, against the concept of its being a deep rift-valley or a ramp-valley.[2] It is now regarded as of moderate depth, carrying on its Archæan floor about 15,000 feet of sub-recent river alluvium, overlying a shelving bank of older fluviatile sediments of the Siwalik and Murree epochs (Mio-Pliocene). Recently gravity surveys have been interpreted as indicating a lesser depth for these lighter deposits, aggregating only 6,500 feet,[17] resting on the denser bed-rock. The depth of alluvium is at a maximum between Delhi and the Rajmahal hills and it is shallow in Rajputana and between the Rajmahal hills and Assam. The floor is probably not an even plane, but is corrugated by inequalities. An upwarp of the Archæan rocks in structural prolongation of the Aravalli axis is referred to above. This fact, in conjunction with the observation† of some traces of an older anomalous transverse strike, diagonal to the direction of compression of the Himalaya in the sub-Himalayan belt of Garhwal, suggests that the Palæozoic orogeny of India has not interfered materially with the Himalayan orogeny. It has however played a part in modifying the shape of the Indian trough, producing two festoons on the southern border west and east of the Delhi wedge, the synclinorium being narrowest between Delhi and Hardwar. It was Suess who first regarded the great Indian trough as a 'foredeep', the Peninsular

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* A memoir on the Salt Range by Mr. E. R. Gee is under preparation.

† C. S. Middlemiss : *Mem. Geol. Surv. Ind.*, Vol. XXIV, p. 183, (1890).

shield sagging in front of the advancing crust-folds. The boundary between the trough and the Himalayan foot is marked

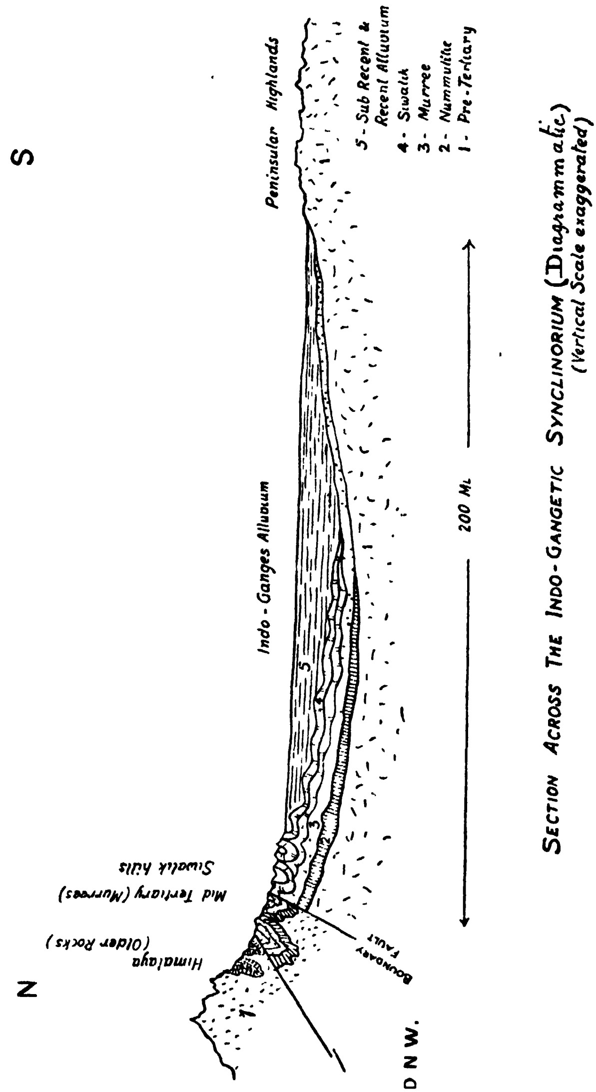



Fig. 3.

by lines of parallel reversed faults [1] which, within certain limits can be interpreted as delimiting the boundary of the Outer Himalaya at several successive periods of its uplift, from the

Eocene to the end of the Pliocene. These reversed faults, designated as the 'main boundary faults', can be traced from the Punjab to the Eastern Himalaya, though they cease to be of the nature of limits of deposition of piedmont sediments in the Assam region in the East and in the Poonch hills in the extreme North-West in Kashmir.

Northward of these fracture-lines are the great thrust-planes along which slices of the mountains have moved to the south, bringing pre-Tertiary rocks of the inner Himalaya in contact with the late Tertiaries of the foot-hill zone. A number of such thrusts have been lately mapped in the west and central Himalaya. The southern limit of the trough shows no structural peculiarities or features of any importance.

The floor and northern border of the great trough is presumably under mechanical strain due to the progressive downwarping, with the greatest subsidence in the sector adjoining the mountain-border. Combined with this is the severe plication along the whole northern rim. It is conceivable that the alluvium conceals a zone of similar folding and faulting further south. The earthquake belt of India runs along the north margin of the plains from the Malay arc to the Iranian arc. The seismic instability of this part of India is well known, it being the site of the epicentres of the great majority of the known Indian earthquakes.

### 4. *The Assam Plateau and Assam Valley.*

In its composition as well as in geotectonics the Assam ranges and plateau are a part of the gneissic mainland of the Peninsula, being its north-easterly promontory, in strike continuation of the Hazaribagh and Rajmahal hills. Along with the gneiss, some patches of a few of the characteristic Peninsular formations are observed in Assam, e.g. the Dharwars, Lr. Gondwanas (according to C. S. Fox), the Sylhet trap, Upper Cretaceous of Trichinopoly facies and laterite. The intervening Malda gap is due to the erosion of the connecting rocks by the shifting channels of the Ganges and Brahmaputra and to the filling up of the hollow by comparatively shallow alluvium. As in the case of the north-west, or Kashmir cape, this tongue of the foreland has probably played a large part in moulding the axial bend of the Eastern Himalaya around it, as we shall see in the sequel. The post-Archæan rocks of Assam plateau are unfolded and horizontal, as is so generally the case with the Peninsular formations; though on either side of the plateau, to the north and south, at a distance of only a few miles, the Tertiary rocks are plicated, overturned and overthrust, both in the Himalayan foot-hills and in their strike continuation, the Patkai and Naga ranges.

In its geotectonics and in the way in which it has reacted to the crustal movements on its three sides, the Assam promontory of the Gondwana horst is of the highest interest to geologists.

Sketch Map of Upper Assam

(after P. Evans, Trans. Min. Geol. Inst. India Vol. XXVII p. 165)

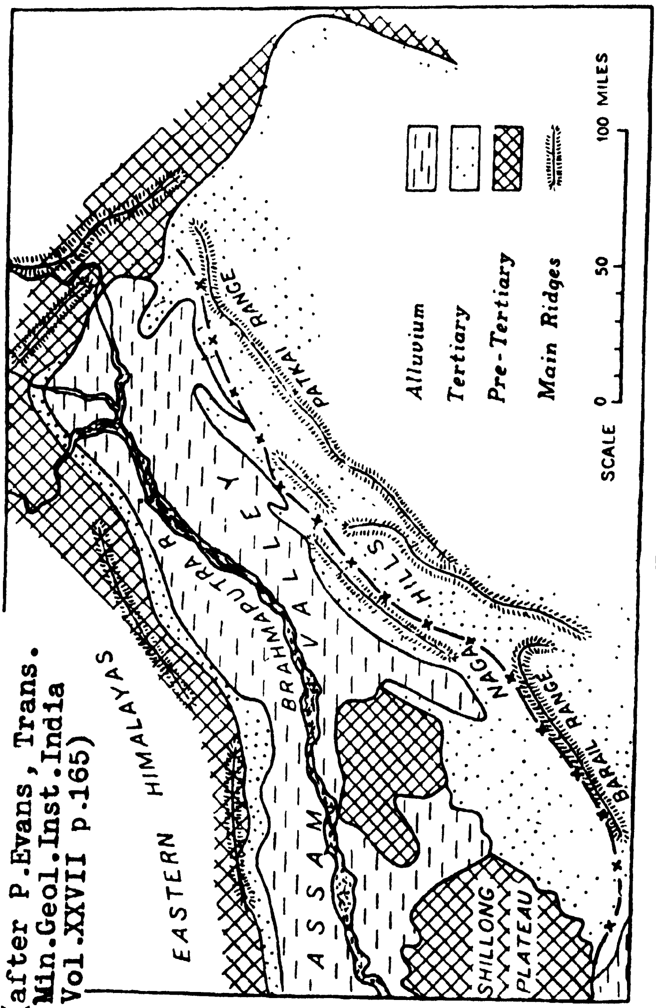



FIG. 4.

According to C. S. Fox and P. Evans, who have carried out detailed field work in the Assam hills and the plateau country,

the Assam valley, deeply buried under the Brahmaputra alluvium, is underlaid by the Archæan rocks of Assam, and is a good example of a 'ramp valley' that has by pressure and overfolding been so jammed that its present breadth is only a small fraction of the original. During this process the central granite massif of the Shillong plateau, which acted as the pivot against which the mobile crust moulded itself in a syntaxial bend of the mountains, has not emerged unaffected. According to Fox, the Shillong massif, which presents a long gentle slope towards the Eastern Himalaya, and a steep scarp face to the south, is rent by N-S running cross-faults, which have sliced the plateau into blocks pushing them southwards *en echelon*.

## II. Structure of the Himalayas.

We must now turn to consideration of the structure of the Himalayas which rise abruptly from the plains covering the foreland. The edge of the plains, however, does not represent the boundary of the foreland, but as we shall see, a considerable width of the latter is covered under the sub-montane Tertiary deposits of the foot-hills (Sub-Himalaya). The outermost of the thrust-planes discussed in the sequel may be taken to be the real boundary of the Himalayan geosyncline with the Gondwana coast land.

### 5. *The Hazara-Kashmir Syntaxis.*

The trend-line of the Himalaya is determined by the shape of the Archæan massif of Gondwanaland which is believed to have played a passive rôle against the weaker crustal zone of the Tethys geosyncline pressing southward. For 1,500 miles, from Assam to Kashmir, the Himalayan ranges follow one dominant orogenic strike, at first E.-W., later S.E.-N.W. and then appear to terminate suddenly at the peak of Nanga Parbat (26,620), one of the greatest eminences on the central axis. This abrupt termination was a puzzle; topographic surveys failed to find any line of heights to continue the chain west of the Indus. Geological survey of the country,[10] however, clearly showed a sharp southward bend of the mountain-strike on itself, pursuing at first a south and then a south-west course, through Chilas and North Hazara, instead of pursuing a north-west course through Chitral. All the geological formations and the axis of every individual fold follow this sharp hair-pin bend of the strike as if bent round the pivot of Nanga Parbat. This inflexion, moreover, is not confined to the central ranges only, but it affects some 300 miles depth of the mountains from the Punjab piedmont to the Pamir plateau, which itself shares the same flexure. On the western side of the syntaxis, the Himalayan strike sweeps from the prevalent N.E.-S.W.

to a S.-N. direction in Upper Hazara and continues so to Gilgit (Latitude 36°N.), then it turns W.-E., the Pamir plateau showing a distinct equatorial disposition of the fold-lines. To the south and east of this the main tectonic strike, or 'grain' of the mountains in Astor and Deosai quickly takes a N.W.-S.E. orientation—a direction which gradually changes to a W.-E. trend in Sikkim and Assam. Suess explained the above phenomenon as due to the meeting and conflict of the two opposing orogenic systems of the Himalaya and Hindu Kush, both suffering a deflection and undergoing an acute bend at the line of contact. Stratigraphic and geotectonic facts, as brought to light in detailed field work in this area are, however, decisive against two systems of orography being concerned here, but prove a remarkable identity and continuity of the Himalayan system on the two flanks of the syntaxis. Not only do the stratigraphic systems of Kashmir pass over into Hazara round the re-entrant, but the individual fold-systems and their structural relations with one another are also identical.

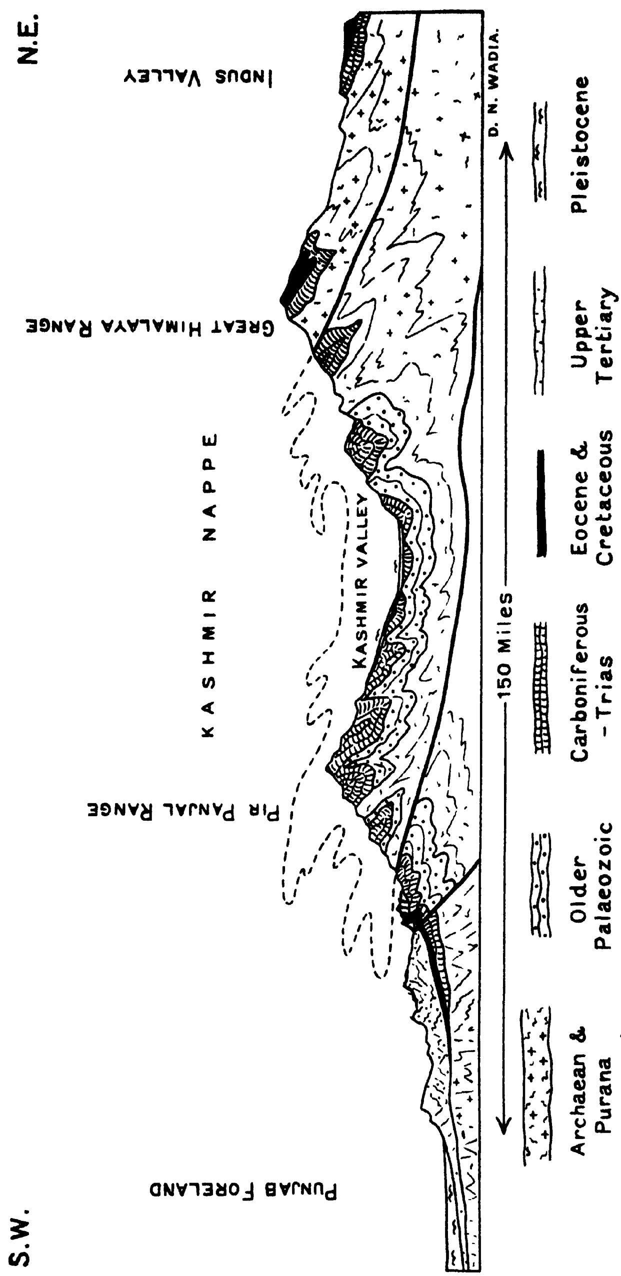
Wadia in 1931 suggested that the acute bend is due to the moulding of the Himalayan orogeny as it emerged from the Tethys round a tongue-like projection of Gondwanaland—the Punjab wedge. On meeting with this obstruction, the northerly earth-pressures resolved into two components, one acting from the north-east, the other from the north-west, against the shoulders of this triangular promontory. Thus it has happened that the Hazara mountains are in their geological structure and composition, a replica of the Kashmir mountains. Westward the axial continuation of the Himalayan geosyncline is observable as far as Campbellpur, beyond which it will be decided by future field work in the Irano-Afghan frontier.

Tectonically the Kashmir Himalaya consist of three structural elements :

(1) The tongue of the *foreland*, its peneplaned surface being buried under a thick cover of Murree (Miocene) sediments.

(2) A belt of *autochthonous*, mainly recumbent, folds consisting of rocks ranging in age from Carboniferous to Eocene, thrust against and over the foreland covered under Murree series (Murree thrust). Southward over-folding and thrusting, with a dominant north-east dip, is the prevalent structural tendency of this region.

(3) The *nappe zone* of inner Himalayan rocks which has travelled far along a horizontal thrust (Panjal thrust) so as to lie fitfully sometimes against a wide belt of the autochthone, at other times almost against the foreland. The Kashmir nappe is composed mostly of pre-Cambrian sediments (Salkhala series) with a superjacent series (Dogra Slate), forming the floor of the Himalayan geosynclinal that has been ridged up and thrust forward in a nearly horizontal sheet-fold. On this ancient basement lie synclinal basins containing a more or less




SECTION ACROSS THE KASHMIR HIMALAYA TO SHOW THE BROAD TECTONIC FEATURES.
(Diagrammatic)

FIG. 5.

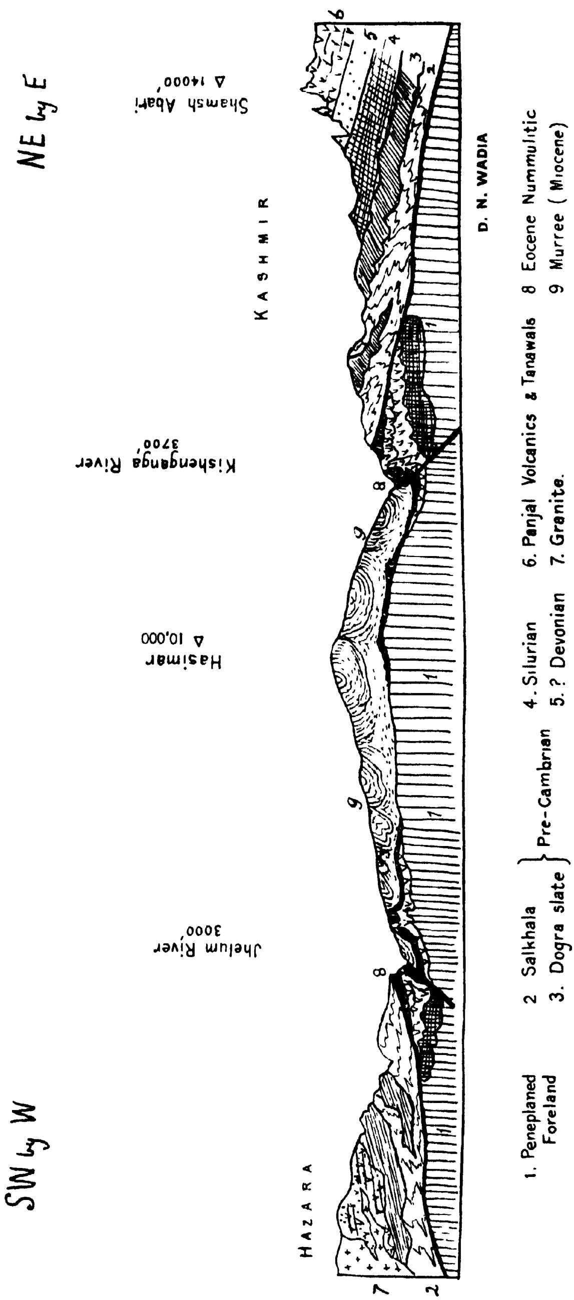
full sequence of fossiliferous Palæozoic and Triassic marine deposits in various parts of Kashmir. The latter are detached outliers of the Tibetan marine zone, which in the eastern Himalaya is confined to the north of the central Himalayan axis.

The most important tectonic feature of this region is the occurrence of two great concurrent thrusts on the southern front of the Himalaya, delimiting the autochthonous belt, which have been traced round the re-entrant from the Hazara border to Dalhousie, a distance of 250 miles. Of these two thrusts, the inner one (Panjal thrust) is the more significant, involving large scale horizontal displacements. The outer, the Murree thrust, shows greater vertical displacement and is steeper in inclination but has an equal persistency over the whole region. In its geological structure, the autochthonous zone between the two thrusts is composed of a series of inverted folds of the Eocene (Nummulitic) rocks, enclosing cores of Upper Carboniferous, Permian (Panjal volcanic series) and Triassic, closely plicated and sheared, but with their roots *in situ*. See Plate V.

In the nappe zone to the north are more thrusts, not easily recognisable in the crystalline complex which builds the Great Himalayan range of the centre. These thrusts, however, are not of wide regional or tectonic significance. As a tectonic unit, the Great Himalayan range is made up of the roots of the Kashmir nappe, the principal geanticline within the main Himalayan geosyncline, consisting of the Archæan and pre-Cambrian sedimentary rocks together with large bodies of intrusive granites and basic masses. Several periods of granitic intrusions have been observed, the latest being post-Cretaceous, or still later, connected with the earlier phases of the Himalayan uplift. A subordinate element of the Great Himalaya range is formed by the southward extensions of the representatives of the Tibetan belt of marine formations belonging to the Palæozoic and Mesozoic.

### 6. *The Nappes of the Simla Himalaya.*

Detailed mapping and study of the metamorphic gradations in ancient rock-complexes have led G. E. Pilgrim and W. D. West to conclude that the rocks of the Simla-Chakrata area, lying to the north of the Tertiary belt (Outer Himalaya), are not in the normal position as previous observers had believed, but have undergone complex inversions and thrusting.[14, 15] Four overthrusts are noted which have trespassed over the 64 miles broad Upper Tertiary area of Kangra and constricted it to barely 16 miles at Solon. The thrusts represent flat recumbent folds of great amplitude, showing bodily displacement



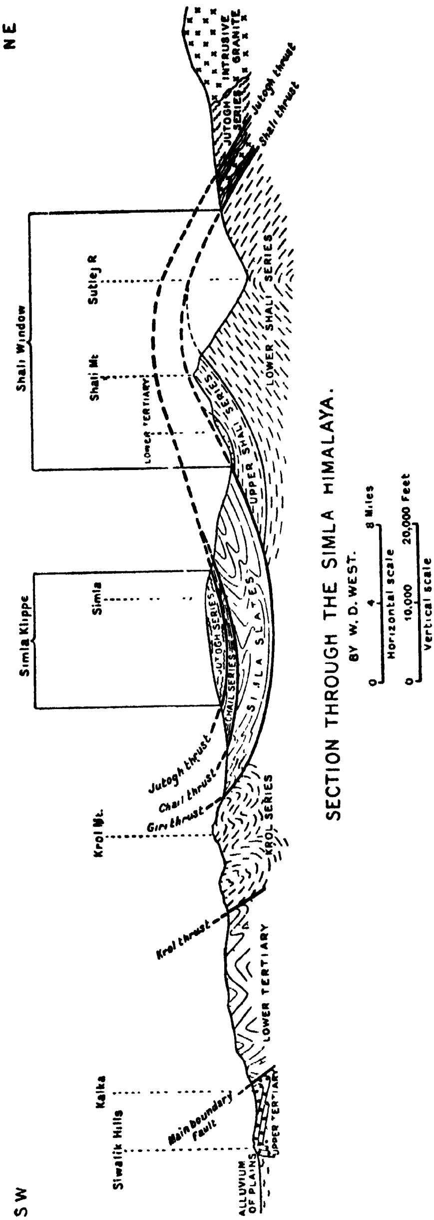

SECTION ACROSS THE HAZARA-KASHMIR SYNTAXIS: RELATION OF THE FORELAND WITH AUTOCHTHONOUS & NAPPE ZONES

FIG. 6.

from the north towards the autochthonous belt of the south-west. The pre-Cambrian (Jutogh and Chail series) is piled up on the Carboniferous and Permian systems (Blaini and Krol series), the entire sequence being totally unfossiliferous. Evidence of the superposition of the highly metamorphosed pre-Cambrian (Jutogh and Chail series), building some of the conspicuous mountain tops of the area (Klippen) over the less altered Lower Palæozoics and Blaini beds (Upper Carboniferous), is obtained by a study of relative metamorphism and the structural relations of thrusts and discordances. The older rocks, now isolated, were once part of a continuous sheet over this area but are now separated from the roots in the north by the deep valley of the Sutlej. To the south of the thrust zone, in the foothills, the olderTertiaries (Nummulitics) are separated from newer Tertiaries of the foot-hills by the series of parallel reversed faults which have been designated as boundary-faults: (1) separating the Upper Tertiary from the Lower Tertiary, and (2) separating the Lower Tertiary from pre-Tertiary rocks. This last 'boundary' fault is really an overthrust corresponding with the Murree thrust of the Kashmir mountains. Medlicott, Oldham and Middlemiss regarded these faults and thrusts not as dislocations but also as limits of deposition, no Upper Tertiary occurring north of the outer fault and no Upper or Lower Tertiary occurring north of the inner fault. Though this conception still holds true to a large extent there are exceptions, here, as in the other parts of the Himalaya, viz. the occurrence of Nummulitic and later Tertiaries to the north of the inner line of faulting.

The nappe zone of the Simla region makes a more striking feature than in Kashmir. It commences some miles north of Solon and follows a meandering E.S.E. course separating the Krol (Permo-Carboniferous) belt by the two great thrusts, Jutogh and Giri, which correspond with the Panjal thrusts of the western Himalaya. The outer limit of the Krol belt is the Krol thrust, corresponding to the Murree thrust of Kashmir. As shown by West and Auden, the Krol thrust itself is steeply folded by later disturbances which have plicated the Krol belt. This Krol belt,[19] which tectonically corresponds with the Panjal range of Kashmir Himalayas, extends along the Outer Himalayas for 180 miles south-east of Solon in a tightly compressed sequence of Permo-Carboniferous strata. Near Solon, Tertiary rocks crop out as windows from under the Krols.

East of Nahan the Krol thrust transgresses southwards and overlaps the main boundary fault. Broadly speaking, the Krol zone of Simla corresponds with the autochthonous fold-belt of Kashmir, but as with the latter area, the autochthone is often greatly narrowed and at places obliterated by the approach of the nappe-front of the gently inclined over-thrust slices from the north. Here and there as at Solon, the Krol zone itself is deformed and thrust forward over the Nummulitics.




SECTION THROUGH THE SIMLA HIMALAYA.
BY W. D. WEST.

FIG. 7.

W. D. West is continuing the field work to the north in this area and is tracing the continuity of the nappes to the root zone in the crystalline area beyond the bend of the Sutlej. He has mapped in the Shali-Sutlej area a 'window' exposing younger rocks by the denudation of the overlying older rocks. The sides of the window are formed of the Chail series showing an *epi* grade of metamorphism. Within the window there occur Upper Palæozoic, Nummulitic and Miocene rocks, dipping centrifugally beneath the Chail cover. The base of the Chails is a plane of mechanical contact and marked discordance, some recumbent folds and thrusts being developed in the Tertiary strata immediately beneath the Shali thrust.

Massive porphyritic granite is intruded on a large scale into the pre-Cambrians. This granite is part of the central crystalline axis of the Himalaya, as in Kashmir and Hazara.

7. *The Superposed Nappes of the Garhwal Himalaya.*

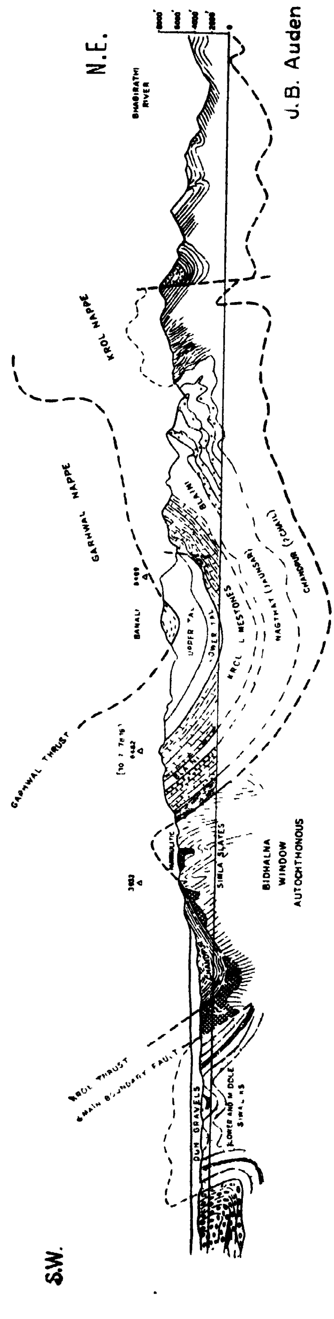
The tectonics of this part of the Himalaya is discussed in a recent paper by J. B. Auden.[20] Two nappes, the Krol and the Garhwal nappe, are superposed one on the other and thrust forward to the obliteration of the autochthone at places. Middlemiss' and Griesbach's previous study of this section of the Himalaya had given, in conformity with the tectonic ideas prevalent then, a simple interpretation to the profile across the Garhwal Himalaya, involving no horizontal displacements [1]

Proceeding north-east from the Sub-Himalayan Upper Tertiary zone (Siwalik and Dagshai), there are encountered, according to Auden, the following well-defined units :—

(1) The autochthonous fold-belt comprising a substratum of Simla Slates folded in with the Eocene, Dagshai and Siwalik series. Its outer boundary is the reversed fault, 'the main boundary fault' of Middlemiss.

(2) The Krol nappe, comprising a thick succession of rocks in the Krol series (probable Permo-Carboniferous) overthrust upon the Nummulitics and Dagshai of (1). The maximum thickness of the succession in the Krol nappe is of the order of 20,000 feet. This sequence is a normal one and there is no inversion due to recumbent folding.

(3) The Garhwal nappe superposed on the Krol nappe, the relations being such that the Nummulitic, Jurassic and Krol rocks belonging to the underlying Krol nappe, completely surround the older Palæozoic metamorphosed and schistose series of rocks of the superincumbent nappe and dip below them in a centripetal manner. The two major thrusts of the area are seen in Fig 8. The outer, Krol thrust, is continuous with the Giri thrust of the Simla hills and runs south-east beyond Naini Tal. The inner, Garhwal thrust, is not a continuous




The Garhwal Nappes

FIG. 8.

plane but circumscribes cake-like masses of older rocks lying over the Krols in detached 'outliers'.

(4) The Great Himalayan range of crystalline phyllites and schists made up of metamorphosed elements of the Garhwal nappe (which had its root in this part) together with the phyllites, paragneisses and schists, and intrusive granite bodies. It marks roughly the apex of the geanticline within the main geosyncline of the Himalaya.

(5) The Tibetan zone of fossiliferous sediments ranging in age from Cambrian upwards to the Cretaceous is confined to the north of the last zone in this part of the chain, unlike Kashmir, where it occurs considerably to the south of the crystalline axis as well. The high peaks of the snowy central range of the Himalaya, generally composed of granitic rocks define the southern limit of this zone.

### 8. *Eastern Himalaya—Mount Everest Region.*

The successive Mount Everest expeditions have brought forward data from which it is possible to interpret the tectonics of this region. The stratigraphical work of A. M. Heron,[7] N. E. Odell and later of L. R. Wager[21] enable us to do this. Both the Tertiary (Siwalik-Nummulitic) zone of the foot-hills and the autochthonous belt are greatly narrowed and obliterated in this part, though the tectonic relations indicate the same large-scale inversions and thrusts. The Siwaliks are in mechanical contact with the terrestrial and fluviatile Permian Lower Gondwana beds (autochthonous), which again are overthrust northwards by the pre-Cambrian Daling series of Darjeeling. This thrust bounds the nappe zone of this area, which has here transgressed considerably farther southward over the autochthonous than in the areas we have considered. A broad stretch of undifferentiated crystalline and metamorphic complex, comparable with the Jutoghs and Salkhalas of the western Himalayas, among which the Dalings preponderate, together with intrusive granite and gneiss, builds the mountain-ranges intervening between the thrust-zone and Mount Everest group of high peaks. Detailed field-work in this region may reveal in this basement complex representatives of the Krol and Blaini, embedded in the axial depressions of the horizontally reposing sheet-folds.

Mount Everest and its satellite peaks lie on a culmination of the Great Himalaya range and are largely composed of metamorphosed sediments, originally shales and limestones, now converted to hornfels, finely foliated calc-schists and recrystallized limestones, traversed by muscovite-tourmaline-granite. Mount Everest marks approximately the southern limit of the Tibetan fossiliferous sedimentary zone. Altered and crushed rocks belonging to the latter, rest over the foliated gneissic

complex of Everest in a prevalent northerly dip, commencing with metamorphosed Permian series of shales, limestones and quartzites, containing a brachiopod fauna with some deformed *Productus* and *Spirifer*. The actual summit of Mount Everest (29,002) is composed of a limestone coming below this Permian series. From these bottom Permo-Carboniferous to Permian beds there is an ascending series of strata towards the north encompassing the Triassic and Jurassic system, indicating a decreasing degree of mechanical deformation. In the longitudinal synclinal folds into which these are plicated, Cretaceous and Eocene strata are recognized by their fossils. A broad belt of the Mesozoic and Eocene rocks was traversed by Sir H. H. Hayden and Sir Sven Heden during their travels in southern Tibet.

The Eocene is the newest stratigraphic system detected in the Tibetan zone of the Himalaya from Kashmir to Sikkim. Eocene strata are involved in the earliest system of flexures of the inner ranges at both these localities, as well as in Hundes, where they lie to-day at 20,000 ft. altitude.

From the data available we recognize in the chief structure-zones of the Sikkim Himalaya, eastward prolongation of the tectonic zones of Garhwal, Simla and Kashmir, though in greatly varying widths.

### 9. *The Conjectural Syntaxial Bend of the Assam Himalaya.*

This part of the Himalaya, geologically speaking, is still a *terra incognita* as far as its stratigraphy and rocks are concerned. The tectonics are likewise unknown of the interior parts. Nevertheless the few data that are available from field observations in the Eastern Himalaya, the Abor and Dafla hills, the Sadiya Frontier Tract and the Naga hills permit some tentative views on the strike and alignment of the ranges.[12] The structural strike of the mountains and the disposition of the fold-axes at the above-named localities strongly suggest a deep knee-bend of the Assam Himalaya towards the south, the re-entrant being in this instance deeper and more acute than is the case with the north-western syntaxis. The obstructing block in the present case must be the granite massif of the Assam plateau, connected underground through the Rajmahal hills with the Peninsular horst. (See Fig. 9.)

The south flank of the Assam Himalaya shows a general north or north-westerly dip of the beds, the faults and thrust-planes also hading in the same direction. On the opposite flank of the deep hair-pin bend, enclosing the plateau and the valley of Assam, are the Naga hills, showing south-easterly dips along with a number of strike-faults and thrust-planes, all hading towards the same direction. Percy Evans considers that there is much evident similarity between the disposition of

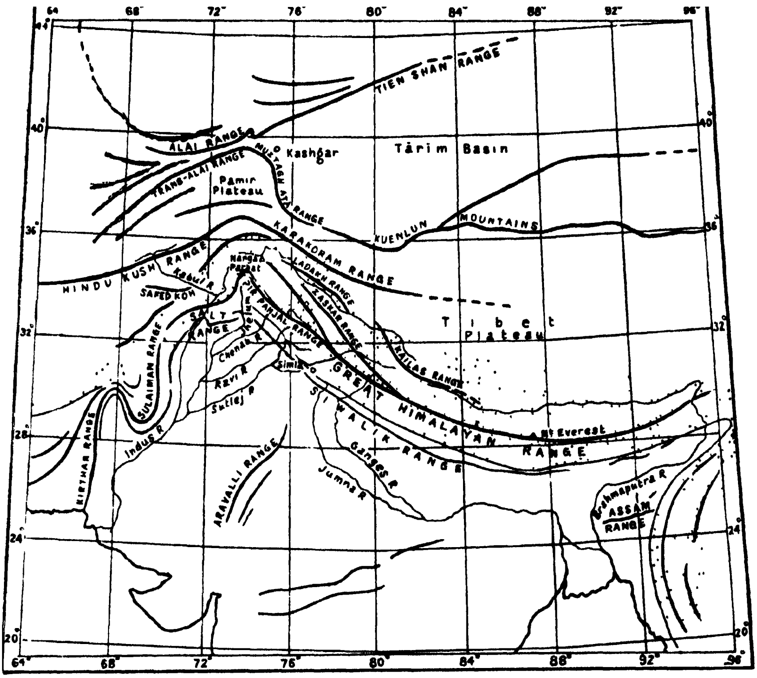
the Tertiary strata of the Assam Himalaya and those of the Naga hills and the age of faulting also, as far as can be ascertained, is the same. The compression of the tongue of foreland enclosed and overthrust by the two flanks of the syntaxis is enormous, as if between the two jaws of a vice.

Palæontological evidence supports the inference that the Himalayan chain bends southwards and does not continue on its eastward alignment into China. The Mesozoic flora of Burma is different from the homotaxial Upper Gondwana flora of India and is more allied to the flora of China—a quite distinct palæo-botanical province from India. This separation of the life-provinces of Gondwanaland and China, lasting from the Upper Carboniferous to the Cretaceous is a fact well established by Halle and Sahni; the cause of this separation can only be attributed to the interposition of the barrier of the Tethys sea. Again, the Cretaceous system of Burma reveals no connection, faunistic or stratigraphic, with contemporary deposits of the closely adjacent Assam province (a part of Gondwanaland), but it shows marked affinities with the Cretaceous of Sind and Baluchistan—a Tethyan province. The Tibetan zone of Himalayan stratigraphy, disposed to the north of the crystalline axis of this mountain chain, extends into Sind on the west side and to Burma on the east.

## III. The Orographic Trends of North India and their relation to the Central Asiatic Mountain-systems.

Recent work in Ferghana (E. Turkestan), and in the Pamir region by the Russian geologists, and in the Himalaya by the Geological Survey of India tends to establish a unity of structural plan and features, disclosing a common cause and origin for all the great mountain systems of Central Asia, both of the Hercynian and of the Alpine age. Fig. 9 is a sketch-diagram showing the alignment of the principal Asian ranges. It is probable, as Argand believes, that powerful crust movements of the Tertiary and post-Tertiary Alpine orogeny superseded, and in a great measure altered, the old Altaid trend-lines of Asia; the existing alignment of all the ranges, therefore, which meet in the Pamir knot, is largely the work of the late Tertiary diastrophism. The orientation of the Tien Shan-Alai-Kuen Lun system of radiating chains in the north, that of the Hindu Kush-Karakoram arc of the middle, and of the deeply reflexed Himalayan arc in the south, all fuse in the Pamir vertex or knot, a crust segment possessing unique significance as having an equatorial strike orientation in the midst of numerous divergent trend-lines radiating away from it. To the south of the Pamirs is the Punjab wedge, the pivot on which are moulded the Himalayan syntaxis and the Hindu Kush–Karakoram syntaxis. This N–S line

of the crust connecting Pamir with Punjab is thus of critical importance in the orography of Asia and will take a key position




**The Himalayan Geosyncline and its relation to adjacent mountain-systems (After Burrard & Mushketov).**

FIG. 9.

in future work on orogenesis and mechanics of crustal motion in mountain-building.

The festooning of the Himalayan arc, caused by the reaction of the more plastic earth-folds pressing against the Indian horst is of great interest. We have seen the two most prominent of these in the Punjab and Assam wedges causing acute looping of the mountain-arcs. An equally abrupt syntaxis of the mountain-folds which belong to the south-eastern flank of the Suleiman bifurcation of the main Himalayan axis as it joins on with the Iranian arc to the west, is seen near Quetta in Baluchistan. This comparatively minor but most spectacular re-entrant shows a bundling up of a multitude of normal anticlines and synclines of Tertiary, Cretaceous and Jurassic strata into a closely packed sheaf and forced out of straightness by

two abrupt curves. These curves, involving a bending of the fold-axes through 120° and 150°, are the result of some crustal peg arresting the free movement of the fold towards the south, under pressures acting from the north or north-west.

From these considerations the view is expressed that the Great Himalaya Range from the gorge of the Brahmaputra in the east to Nanga Parbat on the Indus in the north-west denotes the Himalayan protaxis, the axis of original upwarp of the bottom of the Tethys geosyncline. At both its ends it has undergone sharp southward deflections owing to the termination of the obstruction offered by the north edge of the Gondwana block and its projecting angles and capes.

Stratigraphic and tectonic work in the field have provided no convincing data for fixing with certainty the direction of crustal motion and displacements in the North Indian region, and two contradictory views prevail. The markedly convex trends of the Malayan, Indo-Burma, Himalayan and Iranian ranges, away from the centre of Asia give support to the view which postulates a southward drift or creep of the crust from middle Asia towards Gondwanaland. The irregularities, deviations, and convexities are, on this view, ascribed to the resistances offered by the irregular front of the rigid blocks of Peninsular India, Arabia and perhaps to a less extent north-east corner of Africa. The alternative view does not regard Gondwanaland as a passive resistant block only, but as an active agent in pressing the plastic geosynclinal strata of the Tethys basin northwards. It does not credit a single, united southward movement as competent to produce the convexities of island and mountain arcs (the Pacific arc facing east and the Himalayan facing south-west), but regards underthrusting of the ocean floor and a positive northward drift of the Indian foreland as a more probable source of crustal compression. The latter view has the plausible support of isostasy. For, on a lateral or radial spreading out of Central Asia, there ought to be a defect of matter in the Tibet-Mongol region, which on the contrary, shows a great superficial excess and has the greatest amount of land-mass protruding above the mean sea-level of any region in the world. A northward drift of continental masses, however, remains to be proved. Measurement of the astronomical latitude at Dehra Dun and elsewhere in India has been repeated at different times during the last 100 years ; the results have shown a few irregular changes, but there is no suggestion of any continental drift either to the north or to the south.

On the whole the evidence from structures lends support to the view which postulates tangential pressures from the North. Suess, J. W. Gregory, Bailey Willis, Mushketov and the Russian geologists who have worked in the Pamir-Turkestan field, have all assumed this as the main direction of earth-pressure in the post-Tertiary earth-movements of Central Asia and India.

## IV. Gravity Anomalies in the Himalayas.

A volume of data from gravity stations scattered over various parts of the Himalayas has been collected by the Geodetic branch of the Survey of India. Their computation has given results which are at variance with the hypothesis of Isostasy and the views commonly held about mountain compensation. These data reveal a large negative anomaly in the Indo-Gangetic trough area, filled with alluvial deposits, about 18% lighter than average rock and a large positive anomaly, indicating excess of matter in the Outer Himalaya ; while again there is a negative anomaly in the lofty Depsang plateau of Ladak, composed of rocks of normal density. Gravity observations prove that there is a defect of compensation in the outer ranges of the Sub-Himalaya, i.e. the area is one of overload. This defect increases in amount until, according to Oldham, ' at some 50 miles from the edge of the hills it reaches an equivalent to an overload of about 2,000 feet of rock. In the interior of the Himalayas, in the central ranges, observations show that at about 140 miles from the edge of the mountains this overload has disappeared and compensation is in excess.' This fact would indicate that the middle ranges mark a zone of special uplift and that their underload is due to excessive erosion subsequently. These variations in the balance between topography and underground compensation, according to the same authority, lend some corroboration to the theory of support of mountains by flotation but seems to suggest the rather over-reaching conclusion that the growth of the support has been more rapid than that of the range above it ! ' The primary problem then becomes, not as to how the Himalayas are supported at their actual height, but why they are not even loftier ; in other words, the problem is carried one stage further back, from the origin of the range to the origin of its root.'*

These facts are not easily accounted for by Isostasy, but perhaps it is possible to give a satisfactory explanation for the observed discrepancies regarding excesses and defects of mass in the different parts of the mountains on geotectonic grounds, involving a flexuring of the deeper and denser subcrustal layers in the upheaving of the chain. Col. E. A. Glennie of the Survey of India has suggested a ' crustal warp ' hypothesis which seems to offer a possibility of explaining these discrepancies. These crustal warps elevate or depress the denser more basic layers of the sub-crust, which underlie the more acidic rocks of the surface, above or below their equilibrium plane. The theory, however, is still in the stage of examination and trial.[17] Geodetic measurements are charting out regions of excesses or defects of gravity underneath the surface crust in India. From

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* R. D. Oldham : *Quart. Journ. Geol. Soc.*, London, Vol. LXXII, p. ix, (1916).

these observations Burrard's 'Hidden Range' has emerged as a fact—a belt of underground excess of gravity traversing the north boundary of the Peninsula from Orissa to Sind, approximately parallel to the trend of the Himalaya. This hidden chain or range of density, which runs quite independently of surface irregularities or geological composition, was first postulated in 1901* by Sir Sidney Burrard from positive and negative gravity anomalies obtained from deflections of the plumb line at a number of stations along and to the north and south of the axis of this feature. The origin of this remarkable feature of underground geology of India has not received any satisfactory theoretical explanation, though Holland's suggestion† that the excess of density is due to a chain of intrusions of dense dunitic rocks to the upper layers of the crust is so far the only plausible explanation offered. The parallelism of the Hidden Range with the Himalayan protaxis cannot be entirely accidental and may have a structural significance, suggesting an upwarp of the *sima* layers, parallel to the downwarp of the Gangetic trough.

### V. The Age of the Tectonics of Northern India.

Evidence of the extreme youth of Himalayan orogeny has multiplied of recent years. The tilting and elevation of the Pleistocene lake and river deposits of the Kashmir valley (Karewa series) containing fossil plants and vertebrates, to a height of 5,000–6,000 feet; the dissection of river-terraces containing post-Tertiary mammalia to a depth of over 3,000 feet and the overthrusting of the older Himalayan rocks upon Pleistocene gravel and alluvia of the plains have been noted by the Geological Survey of India and other observers. H. M. Lahiri of the Geological Survey has observed clear thrust-faults at the foot of the Siwalik range of Ambala and Hoshiarpur, Punjab, whereby the Upper Siwalik boulder-conglomerate is pushed over horizontally bedded Indo-Gangetic alluvium, whose age he considers cannot be earlier than sub-Recent. De Terra has made during the last few years valuable observations on Pleistocene orogeny in the North-West Himalaya [22] and correlated the earth-movements there to the later phases of glaciation, which in terms of the standard time scale, would be post-Middle Pleistocene.‡ The initiation of Himalayan mountain-building took place in (1) post-Nummulitic, (Oligocene), time at the earliest, since when the two major phases of upheavals, as revealed by clear stratigraphic evidence, are (2) the post-Miocene, which plicated the broad piedmount zone of Murree sediments, and (3) the post-

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* Sir S. G. Burrard: Survey of India, Prof. Paper, No. 5, Dehra Dun, 1901.

† Sir Thomas Holland: Presidential Address, Geology Section, British Association, 1914.

‡ H. de Terra: Memoir on Pleistocene sequence of India, under publication.

Pliocene, continuing late into the Pleistocene, which has uplifted the Uppermost Siwalik sediments containing *Bos*, *Elephas*, and some artefacts of prehistoric Man to a steeply inclined or vertical position in the Punjab foot-hills (Rawalpindi and Kangra). The main downwarp of the Plains of Punjab, Bihar and Bengal was concomitant with (2) and (3) phases of Himalayan elevation.

In the Salt Range and in the Assam ranges, two periods of uplift are recog ized, (1) post-Eocene or Oligocene, and (2) Pliocene, which continued till late into the Pleistocene. This latter diastrophism was probably a sympathetic event accompanying the final Himalayan phase. The Assam plateau has received also an epeirogenic uplift during late Tertiary.

No Mesozoic or late Palæozoic tectonic movement of orogenic description are detected in the Indian foreland, though minor warps, e.g. minor marine transgressions during the Uralian, Jurassic and Cretaceous, which penetrated the heart of the Peninsula, accompanied by block-dislocations have occurred time and again during the long geological interval. The latest orography of the Peninsula is assigned to the post-Vindhyan —pre-Talchir (Uralian) interval which folded the peneplaned Aravalli synclinorium into a rejuvenated chain, involving in its plication a selvage of the horizontally bedded Vindhyans (? Cambrian) on its east flank.

There was no well-defined Caledonian cycle of earth-deformation in India, while the Hercynian revolutions manifested themselves in initiating the Tethys and in bringing about wide changes in land and water distribution, in tensional faults in the Peninsula, but not in the creation of folded mountains.

The plan of the great edifice of the Himalayas is discernible only in the haziest outline yet. We cannot be so bold as to say that the Himalayas are built on the plan of the Alps, nor even that their architecture is individual. No doubt several tectonic features are common and the Alpine-Himalayan axis of earth-folding originated in one common and continuous impulse. But the proportions are so vastly different, that the very magnitude of the earth-waves raised in the case of the Himalayas gave them a comparatively simpler tectonics, while the smaller convolutions at the other end of the axis may have more severely plicated the shallower surface folds;—the one may be like an ornately built, delicately chiselled chapel, the other a huge sun-altar of rough-hewn blocks. Perhaps the old pioneers who worked before us recognised this fact and I hope those that follow will not entirely ignore this factor.

Gentlemen, I thank you for your courtesy.

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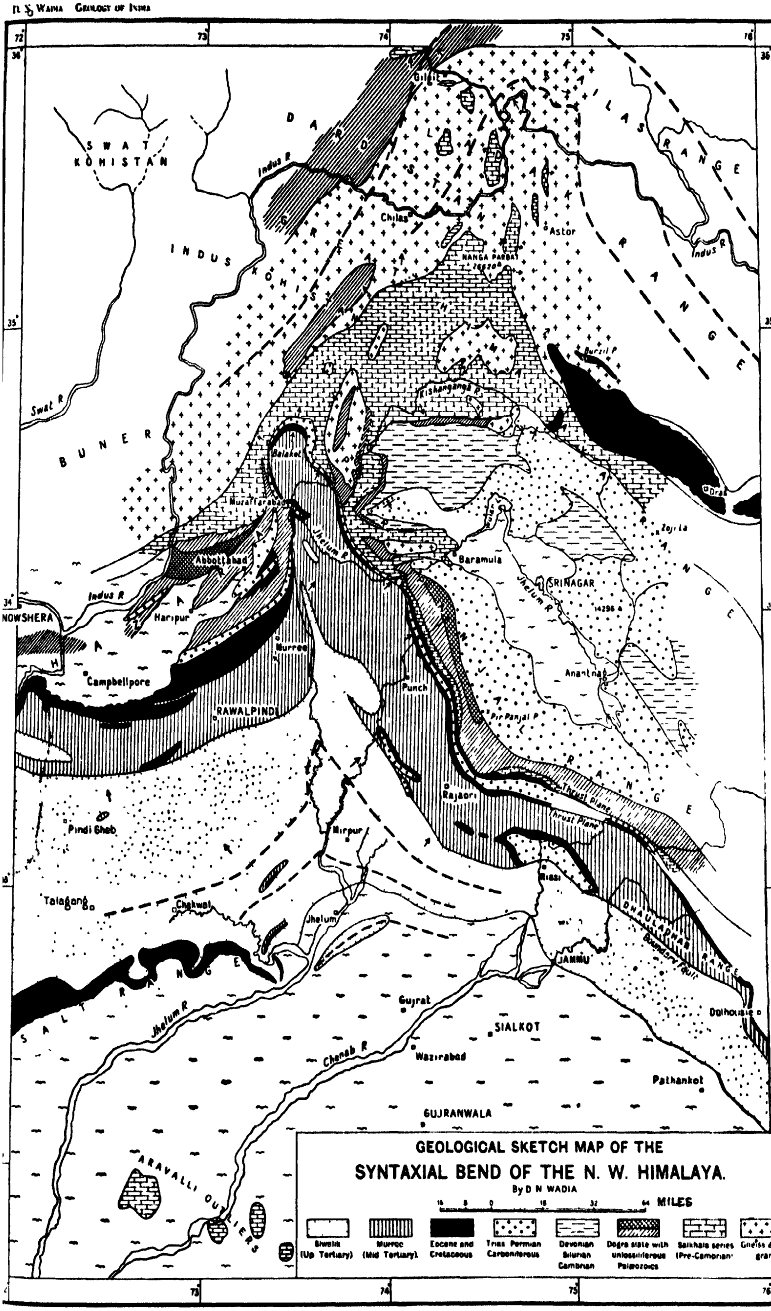

# SECTION OF GEOGRAPHY AND GEODESY

*President* :—A. M. HERON, D.Sc., F.G.S., F.R.G.S., F.R.S.E., F.N.I., F.R.A.S.B.

## *Presidential Address*

### THE PHYSIOGRAPHY OF RAJPUTANA.

As this is the first meeting of a new section, I am fortunate in being spared invidious comparison with preceding presidential addresses, but although there would appear to be a wide choice of subjects upon which to address you to-day, I am limited by my experience.

As I have spent most of my working life in Rajputana I propose to say something about the physical features of that country, especially of the Aravalli range. A condensed account of its geology is given in the *Transactions of the National Institute of Sciences of India*, Vol. I, No. 2, (1935).

First as to its size and shape. It is roughly a rhomb in shape, with east-west and north-south diagonals, the former about 540 miles long, the latter about 510. Its area is 130,462 square miles.

The Aravalli mountains intersect Rajputana from end to end in a line running north-east and south-west, from Delhi to the plains of Gujarat, a distance of 430 miles. They are a true folded mountain range, deeply eroded it is true, but still with several summits exceeding 4,000 feet in height, and are probably the oldest folded mountains on the globe which still remain as a range.

The principal geological interest of Rajputana is in its extraordinarily well developed Precambrian and Archaean succession of six separate systems or series divided by five mappable erosion unconformities :—(1) The Banded Gneissic Complex and the Bundelkhand gneiss, (2) the Aravalli system, (3) the Raialo series, (4) the Delhi system, (5) the Malani series, (6) the Vindhyan system. It is impossible to estimate the immense thickness of sediments involved, but their base must reach very far down indeed into the Archæan.

Three-fifths of Rajputana lie north-west of the Aravallis and two-fifths to the south-east.

The north-western division is sandy, poorly watered and sterile. The eastern part is known in a general way as *Marwar*, a word which is supposed to mean 'the region of death'. This, however, implies an exaggeration, for it is a healthy country with

large villages and towns, though widely spaced. Its hardy people emigrate freely to other parts of India as traders and manual workers, and it supplies large numbers of men to the Army. In the west it is more nearly a desert, the *Thar*, a land of sandhills of the *seif* type of North Africa, long narrow ridges running parallel to the south-westerly direction of the prevailing wind; they may be as much as 200 feet in height and 2 miles in length. The *barchan*, or transverse, crescentic, type becomes more common to the north and east, and there are great areas of gently undulating country of whale-backs of sand, waves which appear to be fixed and are thinly dotted with stunted shrubs and tussocks of grass. The central area, containing the Jurassic outcrops of Jaisalmer, Barmer, Bap and Pokaran, has fewer sandhills, and along the north-western foot of the Aravallis is a more fertile tract called *Godwar*, watered by short streams draining the steep north-western slope of the Aravallis. These streams from the Aravallis unite to form the Luni River, which in floods enters the Rann of Kachh. Except for the Luni catchment the rest of western Rajputana is a land of enclosed drainage where the run-off after the rare heavy showers accumulates in innumerable casual depressions amongst the sandhills; some of these have been of sufficient permanence to give rise to deposits of salt and soda. Of these the greatest is the well-known Sambhar Lake, one of the principal sources of salt in India. The Sambhar Lake covers an area of 90 square miles when full, but it is very shallow and generally dwindles to a mere central puddle in the hot weather. It has been found that the average content of sodium chloride in the upper twelve feet of mud is 5·2 per cent., giving a content of salt stored in these upper layers of at least fifty million tons. As the average production is less than a quarter of a million tons per annum, there is no immediate likelihood of exhaustion. The salt is derived from the Rann of Kachh, blown up by the south-west wind in the hot, dry weather and washed into these depressions by the first heavy showers of the monsoon.

The sand of the dunes of Western Rajputana probably has its origin partly in the Rann of Kachh, 'driven by the south-westerly gales which blow across the desert for several months of the year and unimpeded in its advance by streams of running water, it has encroached upon the land until no district is entirely free from it, except those lying immediately at the foot of the Aravalli range, where the numberless water-courses descending from the hills, although they contain running water for only short periods, are able to sweep back the sand blown into them '.[1]

La Touche[2] has noted the presence of fossil foraminifera,

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1 T. D. La Touche, *Mem. Geol. Surv. Ind.*, 35, Pt. 1, p. 37, (1902).
2 *Ibid.*, pp. 39-40.

derived from the Tertiary rocks of Kachh, to a distance of 500 miles from their origin.

The sand is banked up along the south-western flank of any rocky ridge facing the plain, that is on the windward side, and in the lee of any knoll or small ridge forms a tail extending to the north-east. Between the rock and the sand there is usually a deep narrow ravine, kept clear by the concentrated drainage from the rocks.

Where there are gaps in the Aravalli range, as for instance at the Sambhar Lake and east of Sikar, the dunes extend for miles over the eastern plain, right up to Jaipur City.

Between the foot of the hills and the Luni the country is fertile and water lies near the surface, enabling well-irrigation to be done, but to the westward the cultivation becomes patchy and poorer as the loam shades off into the sandy waste (the *Thar*), while the water-table sinks lower and lower until in Bikaner it is necessary to go down 350 and 400 feet, and even then the water is often brackish.

With a good monsoon, however, which may be reckoned as 10 or 12 inches, even this arid land is covered with light vegetation which supports great herds of cattle, goats and camels.

I quote from Aldous Huxley's ' Jesting Pilate ' his description of the Bikaner landscape :—

> ' Once in every ten or twenty yards, some grey-green plant,[1] deep-rooted, and too thorny for even camels to eat, tenaciously and with a kind of desperate vegetable ferocity struggles for life. And at longer intervals, draining the moisture of a rood of land, there rise, here and there, the little stunted trees[2] of the desert. From close at hand the sparseness of their distantly scattered growth is manifest. But seen in depth down the long perspective of receding distance, they seem like the in fact remotely scattered stars of the Milky Way—numerous and densely packed. Close at hand the desert is only rarely flecked by shade ; but the further distances seem hedged with a dense dark growth of trees. The foreground is always desert, but on every horizon there is the semblance of shadowy forests. The train rolls on, and the forests remain for ever on the horizon ; around one is always and only the desert.'

The solid geology of western Rajputana has little effect on the topography, for the rocks are deeply covered by alluvium except where groups of steep, bare hills vary the monotony.

In the south there are gently folded ancient acid volcanic lavas and their associated hypabyssal granites, granophyres and porphyries (the Malani series), lying unconformably on a basement of Archæan rocks (Aravalli schists and pre-Aravalli

[1] *Calligonum polygonoides*, ' phog ': *Aerua lanata*, 'bhui '.
[2] *Prosopis spicigera*, camel-thorn, ' khejra '.

gneisses), the latter forming hardly any physical feature. Under the insolation of an arid climate, the lava rocks assume strikingly jagged outlines with the smooth desert patina covering their cracked interiors, while the granites are exfoliated and honeycombed into domes and tors, with perched blocks and boulders like cannon-balls and sacks. This is especially the case with the Erinpura granite, post-Delhi but pre-Malani in age, which around Mount Abu and Erinpura gives rise to a tract of bizarre detached hills separated from the main Aravalli range and culminating in Guru Sikar, 5,646 feet. To the north, around Jodhpur, these igneous rocks are overlain by horizontal red sandstones and cherty limestones attributed to the Vindhyan system. The excellent richly tinted building stone which they yield has been utilized to the best advantage in the rose-red cities of Jodhpur and Bikaner and to the vertically scarped, flat-topped hills they form is due to the dramatic appearance of the Jodhpur Fort. Chitor Fort, on the eastern plain of Mewar, is built on a similar cake, but larger, of Vindhyans.

To the north-west, in Jaisalmer and Bikaner, are extensive slightly elevated areas of Jurassic and Eocene rocks, largely limestones, forming rocky plains scored by the wind-blown sand.

South-eastern Rajputana is morphologically more varied. Essentially it consists of a gneissic plain, typically irregular, of Archæans, which slopes gently eastward from the foot of the Aravalli range to the plains of Hindustan. Its maximum height is about 1,900 feet. This is *Mewar* proper (the stony plains of Mewar, as Kipling calls it), the heart of Rajputana, where the Rajput social order of chivalry attained its purest development and persists with but little change to the present day. Though the soil is thin and stony, it is a fairly well-watered country, with numerous rivers, mere trickles in the dry season, but the tributaries of which are impounded in many large storage reservoirs, facilitated by the ribs of quartz, pegmatite, quartzite and harder rocks which diversify the gneisses. The drainage falls into the Banas, which joins the Chambal and by it finds its way into the Jumna.

In the north of eastern Rajputana this sloping plain falls below the level of the Indo-Gangetic alluvium, but the covering of alluvium does not appear to be particularly thick, and many hills and ridges of quartz-veins, pegmatite and quartzite give clues to the continuation of the gneissic plain below the alluvium.

The great watershed of India, dividing the drainage to the Bay of Bengal from that to the Arabian Sea, passes along the axis of the Aravalli range from the Sambhar Lake southwards as far as Udaipur City. From there, however, it leaves the range and runs south-eastward over the plain.

The tributaries of the Mahi river, which ultimately reach the Arabian Sea, have eroded the plain to the south of the

watershed to a much greater extent than have the northward-flowing streams to the Bay of Bengal. This is due to the fact that the length of the rivers from their headwaters here to the sea is about eight to ten times the distance to the Bay of Bengal than it is to the Arabian Sea. The gradient of the latter is accordingly steeper and their erosive power is greater. To the south of the watershed therefore the country is not a plain as to the north, but is a mass of hummocky country, deeply and intricately dissected, known as the *Bagar* and comprising the 'Hilly Tracts' of Mewar and the States of Banswara and Dungarpur. It is the land *par excellence* of the Bhils, who like to build their scattered huts upon hillocks and burn the scrub jungle for cultivation in the rains. In the valleys the soil is rich in the small patches where it occurs.

In the extreme south-east of Rajputana is the *Pathar* ('stony') or *Uparmal* (meaning 'higher plateau'). This is the western lobe of the Vindhyan plateau of Central India, and consists of horizontal sandstones and shales faulted against the gneisses of the Mewar plain by the Great Boundary Fault of Rajputana. As usual in the Vindhyans, it is a triple plateau of three concentric scarps formed by the outcrops of three strong sandstones with intervening shales. It is a wide, stony upland, with occasional tracts of deep black soil in the circumferential valleys, and transport is peculiarly difficult on account of the three seldom-broken scarps. Adjoining the Great Boundary Fault to the west is a most interesting area of strangely unaltered Archæans, from which the transition can be traced westward from shales, through slates, phyllites, mica-schists to composite gneisses. The basaltic lavas of the Deccan trap flooded over this land up to the base of the Vindhyan scarp. They are now being denuded, laying bare the old land surface over which they flowed, showing that the old pre-trap surface was much the same in relief as that of the present day. To the south the Deccan trap is continuous with that of Malwa, the fertile plateau of Central India.

On the other side of the Great Boundary Fault from the area of unaltered Archæans, the Vindhyans themselves are thrown into folds and faulted along lines parallel to the Great Boundary Fault for a short distance in to the south-east of it, by compression acting from the north-west. This is a striking departure from the almost universally flat lie of the Vindhyans over the great area in which they are developed, and shows that in Rajputana tectonic movements persisted to a geologically much later date than elsewhere than in the extraordinarily stable Indian peninsula and affected the uppermost Vindhyans.

In his paper 'On the Age of the Aravalli Range', Sir L. L. Fermor,[1] considering the range as a *horst*, has advanced

[1] *Rec. Geol. Surv. Ind.*, 62, pp. 403-404, (1930).

three possibilities with regard to the age at which this *horst* was produced. His first two alternatives I think unlikely, as they postulate that the Vindhyan rocks of western Rajputana were deposited in continuity with those of eastern Rajputana and Central India. (He indeed himself rejects the first of these two alternatives, from other reasons.) Now all over Central India and eastern Rajputana, a length of 600 miles, the Vindhyans maintain a remarkable uniformity in their sub-divisions, and are from 4,000 to 10,000 feet in thickness. The Vindhyans of western Rajputana, 100 miles away, are only some 300 feet in thickness, and their sub-divisions are unrecognizably different. It would be unlikely for the Vindhyans to remain constant in their intricate sub-divisions over a length of 600 miles, and then in 100 miles to change their succession entirely and to diminish to a tenth of their thickness, and I accordingly believe that the Aravalli range was in existence throughout the period of deposition of the Vindhyans and separated them into two unconnected areas of accumulation. Fermor has pointed out (p. 405) that if this is the case special shore-line conditions should be present in the Vindhyans on both sides of the range. This is so in the case of the Vindhyans on the western side of the range,—gritty and pebbly sandstones, and coarse conglomerates,—but they are absent on the eastern side, the Vindhyans being as fine-grained as usual. This may however be explained by the fact that the Vindhyans here are truncated by the Great Boundary Fault, and may have been deposited far to the west towards the foot of the range, their former extension having been denuded away on the upthrown side of the fault. I shall return to the question of the age of the Aravalli range later, but I may state here that I favour Fermor's third alternative, that the range is pre-Vindhyan in its period of uplift.

In spite of its name, the Aravalli range is composed mainly of rocks of the Delhi system, the massive quartzites of which are responsible for nearly all the prominent ridges which run along the strike. The Delhi system lies unconformably upon the Aravalli system, and is developed in a geosyncline, with the much softer Aravallis exposed upon the flanks. The Aravallis are mostly phyllites, with inconstant quartzites, which, when sufficiently thick and continuous, participate with the Delhi quartzites in the building up of the mountains. Besides quartzites, dominant constituents of the Delhi system are impure limestones, usually altered to calc-gneisses, which, being very hard, form elevated plains or high valleys between the quartzite ridges. Unexpectedly, as they are younger than the Aravallis, the grade of metamorphism and the amount of igneous intrusion in the Delhis are much higher than in the Aravallis. This is explained by the fact that the Delhis in the synclinorium have been more deeply folded into the crust than the Aravallis on

the flanks, so that they have reached a lower zone of greater temperature and pressure and more intense igneous intrusion.

In plan, the synclinorium of Delhis appears like a double fan. Where the handles of the two fans meet it is about four miles wide, and it is believed to be here a simple syncline. This comparatively narrow width is maintained for about forty miles along its length, and then at either end it spreads out into the two fans, by the appearance of additional folds, by a thickening of some of the formations and by deeper folding bringing in higher beds in the central core.

In the northern fan erosion has been more effective than in the southern, and little more than the quartzite ridges of the Delhis remain, the softer upper rocks, phyllites and limestones, being worn away in the synclinal valleys and largely concealed by alluvium. The folds are isoclines, the axial planes of which dip towards the north-west, and they pitch to the north-east. That is to say, the older rocks are exposed to the south-west, the base of the Delhi system being exposed in bays or festoons upon them, and if one passes along the fold-axes towards the north-east one finds successively younger beds coming in.

All along the Aravalli range, if one considers a cross-section of the range at right angles to the strike at any point, one finds that the degree of metamorphism and amount of igneous intrusion increases in a direction from south-east to north-west. So for example in this northern fan of the range, the same generalization holds with regard to the folding. In the furthest east, in the Biana hills,[1] the beds dip at 10°–20° and are little altered. Igneous intrusives are absent. As one passes north-westward the folding steepens to the Jura type, pegmatites and quartz-veins appear, and shales become phyllites. Further north-west still the isoclinal folding I have mentioned sets in and large bosses of intrusive granite appear, with abundant earlier and smaller bodies of basic rock, and a great development of pegmatite in the softer rocks.

The basement beds of the Delhis in this portion of the synclinorium show great thicknesses of conglomerates, occasional tuffs and effusive lavas, and unconformities and overlaps, betokening shore-line conditions and the oscillations of level which take place on a land margin. This land area, corresponding with much of the present Jaipur State, was apparently occupied by the oldest gneisses, and the Delhis were deposited in a sinking tract to its north and east.

The synclinorium narrows from the Sambhar Lake southwards and is seen to consist of two synclines of the Delhis, with a long narrow tongue of pre-Aravalli gneiss between them. An important thrust-fault runs along the north-west of this medial

[1] *Rec. Geol. Surv. Ind.*, 48, pt. 4, pp. 187–193, (1917).

tongue and ultimately brings the two synclines together. This thrust-fault reaches the plain in the neighbourhood of Desuri, but for most of its length it runs within the range and cannot be identified with Sir L. L. Fermor's postulated ' western boundary fault somewhere to the west of the western foot of the Aravalli range '.[1]

The north-western of the two synclines becomes obliterated to the south-west by the intrusion on a large scale of basic and granitic igneous rocks. The south-eastern, as I have mentioned, is more or less a simple syncline for some 40 miles along its length, but south of Desuri it fans out into numerous folds, forming narrow valleys and long bold ridges developed by the quartzites and mica-schists of the lower portion of the Delhis, while much dissected plateaus mark the less complicated structure of the limestones, calc-schists and calc-gneisses of the upper Delhis.

Where the folds disappear under the alluvium of Gujarat the rocks are comparatively unaltered on the eastern flank of the synclinorium, and there is no igneous intrusion. The western flank, however, is saturated with granite and pegmatite intrusions and in the south they invade the central core and replace large areas of the sedimentaries.

I have mentioned the strong quartzites of the Delhis, which give rise to prominent ridges by the mapping of which the structure is apparent. When one looks at these grouped ridges from some distance away, one is at once struck by their wall-like appearance and their long level tops. This was remarked on by the first observer in the region, J. B. Fraser, in 1824. This has nothing to do with stratification, unlike the case of the Vindhyan plateaus built up of horizontal sandstones, for in the Delhis the rocks are usually steeply dipping, or even vertical. When the range is considered as a whole, it is clear that these level summits form remnants of a greatly dissected peneplane. Hardly a single peak projects above their general local level, with the exception of the mountain mass of Abu, which however lies apart to the west of the main range, and is entirely composed of granite. It may still have been mountains rising above the peneplane when the latter had been denuded to a level, or it may be a special elevation.

In the heart of the range, north-west of Udaipur City, the level of the peneplane reaches 4,000 feet above sea-level, falling gradually to the north-east and the south-west along the axis of the range.

In the Alwar hills it lies at a height of 1,800 to 2,200 feet, and to the north, in its last extension in the hills south of Delhi, it falls to 1,000 feet above sea-level, only two or three hundred feet above the level of the plains.

[1] *Op. cit.*, 62, p. 402, (1930).

It was thought by Middlemiss [1] and myself [2] to be traceable down to the floor on which were deposited the Ahmednagar sandstones, a local plant-bearing formation of Wealden, Lower Cretaceous, age, at the southern end of the Aravalli range. Marine transgressions laid down also the Jurassic and Eocene beds of Kachh and western Rajputana, and the Cretaceous Bagh beds. It has since been found, however, that the peneplane does not slope gradually down to the base of the Ahmednagar sandstone, but ends about 400 feet above it. The peneplane is thus older than the Lower Cretaceous by a space of time during which 400 feet of quartzites were eroded, but would still probably be Mesozoic.

Sir L. L. Fermor, in his paper [3] which I have quoted above, argues that the Aravalli tract should be regarded as a horst, bounded on the east by a fault of some 5,000 feet maximum uplift, *i.e.* the Great Boundary Fault of Rajputana, and on the west by a hypothetical or suggested fault of the same order of magnitude, though not necessarily of the same amount; he admits the absence of any observations proving the existence of such a fault. This has not been detected, and if it occurs close in to the western foot of the range I do not think it could have been missed, if existent, for since he wrote the paper Dr. Coulson, Dr. Ghosh and I have been over the country in which we might have expected to find it. If, on the other hand, it runs far to the west of the foot of the range, for instance to the west of the Abu mass, it could easily be missed in the wide stretches of alluvium. Alternatively, if a western boundary fault cannot be found, he suggests a tilt.

Earlier in this address I have pointed out the probability that the eastern and western Vindhyans were deposited in separate basins, and that the Aravalli range was still the barrier separating them.

As I have just said, I prefer Fermor's third alternative—that the Aravalli range was upfolded in pre-Vindhyan times, and the Vindhyans were derived in part from its denudation. At the close of the Vindhyan period this range was still in existence, separating the two Vindhyan areas. We do not know whether it continued to rise *pari passu* with the deposition of the Vindhyans. From the existence of the Great Boundary Fault and the folding of the Vindhyans, up to the youngest, along it, we are certain that at some time after the deposition of the latest Vindhyans we know of, compressive stresses came into action again. How long after this I shall try to indicate, but we do not require to assume the pre-Talchir rejuvenation which Fermor suggests.

[1] *Mem. Geol. Surv. Ind.*, 44, pt. 1, p. 90.
[2] *Op. cit.*, 45, pt. 1, p. 8.
[3] *Rec. Geol. Surv. Ind.*, 62, pt. 4, pp. 402-403. (1930).

Two dramatic cases of superimposed drainage are given by the two principal rivers of Rajputana. Between Rampura and Kotah the Chambal cuts straight through the three Vindhyan scarps, without regard to structure, though its tributaries occupy strike valleys excavated in shales at the foot of the sandstone scarps. The Banas at Rajmahal, wandering through the plains of Jaipur, breaches a great isolated flat-topped ridge of Delhi quartzites in a picturesque gorge, swinging through a right angle before entering it, instead of proceeding on an uninterrupted course round the end of the ridge. The case of the Chambal might be one of 'cut-back and capture', but one cannot believe that of the Banas, where the selection of the only ridge in the neighbourhood for its attack is outside the range of probability. One can only infer that in the case of the Banas its course across the ridge was in existence before the Mesozoic peneplane was warped, and cut down vertically as the plane arched. In the case of the Chambal it is possible that its direction was established when Deccan trap covered the area up to the outer scarp, and that the Deccan trap surface determined the direction of flow.

The range appears to have been peneplaned during the Mesozoic, at some time not very much earlier than the Cretaceous. This may well have been the first peneplanation since the range arose in pre-Vindhyan times. The peneplane has since been warped in such a way that its central portion in Udaipur is now some 4,000 feet above sea-level, its north-eastern end near Delhi about 1,000 feet and its south-western end in Gujarat about 1,000 feet above sea-level. Now land cannot be worn completely down to sea-level, for its base-level of erosion must always be determined by the final gradient of the streams eroding it, below which they cease to operate. This we may try to estimate, for the Aravalli range, by considering the present level of the plains, which will give us values close enough for our purpose, as the plains of India have very nearly reached the stage at which their rivers can no longer eat them away. We may take this as about 650 feet at Delhi, 500 to 700 feet in western Rajputana, west of the centre of the range, and 700 feet on the Gujarat margin.

On these assumptions the uplift of the range, since peneplanation, has been some 300 to 400 feet at its ends, and 3,500 feet as a maximum in the centre.

The maximum figure given for the displacement of the Great Boundary Fault, 5,000 feet, is therefore not far different from the maximum warping of the Mesozoic peneplane, and the throw of the fault is believed to decrease from about the centre of its arc where the maximum occurs, towards either end. Near Chitor, in fact, the upthrow changes from the western side to the eastern.

The suggestion is now made that the elevation of the peneplane, or the Mesozoic rejuvenation of the Aravalli range, and

the production of the Great Boundary Fault, may be closely connected and contemporaneous. It will be seen that the western lobe of the eastern Vindhyans would act as a ram or wedge, which by thrusting under the Aravalli tract from pressure acting from the north-west might tilt it along its eastern side, lifting it from a hinge-line to the west, thus rendering it no longer necessary to suppose a fault along the western side of the range.

It seems somewhat startling to ascribe a late Mesozoic age to a structure which has hitherto been tacitly supposed to be very ancient, but in the closing paragraphs of the paper which I have quoted, Fermor sounds a note of caution in ascribing to present features of India a too great antiquity. We know, of course, of the great faults of post-Gondwana time which have let down the coalfields into the gneisses and preserved them, and Dr. Fox [1] has found that the throw of the post-Deccan-trap fault of the Gawilgarh hills, north of Ellichpur, is at least 1,800 feet and might be as much as 4,000 feet.

In the case of the Great Boundary Fault of Rajputana, we can place an upper limit to its age, for it runs below the Deccan trap, which lies undisturbed upon it, and it is thus pre-Tertiary.

The straight steep western coast of India has been supposed to be a cut-back fault-scarp, the hypothetical fault running at some unknown distance out at sea. This fault, if it does occur, must be later in age than the Deccan traps, as they constitute the supposed fault-scarp. Lt.-Col. R. B. Seymour Sewell [2] has recently made the interesting suggestion that the great submarine ridge which extends due south from the west coast of India, and on which are situated the Laccadive, Maldive and Chagos archipelagoes of coral-atolls, is a continuation of the Aravalli range. It is possible that this submarine ridge was submerged by its foundering on the downthrow side of the hypothetical West Coast fault after the pouring out of the Deccan traps, and therefore at a later date than the rejuvenation of the Aravalli range by compression and faulting acting before the time of the Deccan trap.

On these assumptions the Aravalli range was peneplaned in the Mesozoic, re-elevated before the beginning of the Tertiary, and the southern prolongation of it, now under the sea, was let down in the Tertiary, after the accumulation of the Deccan traps.

A second possible peneplane, but one about the reality of which I am not nearly so certain, is represented by an erosion surface on the softer rocks, phyllites, schists, gneisses and some of the granite areas. This is best developed on the plains to the east of the Aravalli range, but forms the floor of the broad strike-valleys within the range. Rising above it we have not only

[1] *Rec. Geol. Surv. Ind.*, 62, pt. 4, p. 409, (1930).
[2] *Mem. A.S.B.*, Vol. IX, No. 7, pp. 439–442, (1935).

the great even-topped ridges of Delhi quartzite, topped by the Mesozoic peneplane, but many residual resistant masses, due to the harder epidiorites and granites, quartz-reefs, minor quartzites, limestones and such less easily eroded rocks. For considerable areas it may be covered with superficial deposits of no great depth, through which the streams cut down to rock. Its margins dip under the alluvium of the Indo-Gangetic plain and Gujarat. It is not so much a continuous plane as a series of planes, at slightly differing levels, falling in steps from the centre of the range to the plains bounding it. The heights of these planes are determined partly by the character of the rocks of which they are composed, and partly by the extent to which erosion has been retarded in certain of the higher valleys by rock-barriers impeding the drainage and hindering the cutting-down action of the streams. As an instance of the effect of the nature of the rocks on the levels of adjacent parts of this plane, I may mention that the upper portion of the Delhis, above the strong Alwar quartzites, consists of three types of rock, exposed in the heart of the range (1) limestones and calc-gneisses with normally few intrusives, (2) flaggy calc-schists with numerous small pegmatites, (3) mica-schists riddled with small and large pegmatites. These three divisions are intrinsically different in their lithological character and, in consequence, in their behaviour under denudation, the calc-gneisses and limestones being the most resistant and the mica-schists least, and in addition they are weakened by the pegmatite intrusions in them. As a result a set of three stepped planes is developed from them, that on the calc-gneisses and limestones being the highest, forming long narrow plateaus along the range, flanked by shelves cut out in the calc-schists, and bounded by more depressed belts along the mica-schists. Roughly speaking, there may be differences of some fifty or even a hundred feet between the three planes taken at any cross-section, and the modern stream system has deeply incised them all.

If this peneplanation is really a unit, and not a fortuitous effect resulting from the even erosion of foliated rocks which, looked at broadly, are mostly fairly homogeneous, it may perhaps represent the Tertiary peneplane which has been detected in other parts of India, *e.g.* by Dr. J. A. Dunn in Chota Nagpur.

There is yet a third peneplane, of Pleistocene or Sub-recent age, that of the *bhangar*, or older alluvium of the Indo-Gangetic plains. At Agra on the Jumna the level of this is about 170 feet and the tributaries of the Jumna cut into it to a depth of 90 feet. The older alluvium is a yellow clay, somewhat cemented by carbonate of lime, which forms the familiar concretions known as *kankar*, so extensively used all over the plains of India as road metal and a source of lime. It approximates to loess in character and is the combined product of river flood and wind action. *Kankar* is a Hindustani word meaning ‘ gravel ’.

As it has a certain amount of consistency under rainfall, when eroded it stands up with steep slopes, and gives rise to the narrow belt of 'bad-lands' which fringes most of the rivers. This is not well seen at Agra, but where the road and railway cross the Chambal river south of Dholpur, on the way to Gwalior, the fretted sculpturing is impressive, in a maze of tortuous ravines, the topography of which is well displayed on the one-inch map.

To the south, in the centre of Rajputana, where it meets the peneplane or 'pseudo-peneplane' of Tertiary age which I have just mentioned, the alluvial peneplane rises to about 1,400 feet, and on the western side of the Aravalli range it lies at about 1,000 feet. Near the mountains the level of the alluvium rises somewhat rapidly, but this is due to the heaping-up of wind-blown sand in a ramp. The sand-hills of western Rajputana are accumulated on this peneplane, out on the desert away from the hills.

I have put these notes together to attract attention to various points in the tectonics of Rajputana. The structure was evolved first by the intense folding of the ancient Aravalli range, and, more recently, geologically speaking, by faulting and more gentle warping movements which may have initiated the fissure-eruptions of the Deccan traps. As my years in India are numbered, I leave it to my geographical and geological colleagues to test my suggestions in the larger field of the structure of the Indian peninsula as a whole, and, speaking both in a figurative and a Wegenerian sense, its repercussions on the tectonics of the Himalaya.

### List of some papers on Rajputana Geology.


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2. Coulson, A. L.—The Geology of Sirohi State. *Mem. Geol. Surv. Ind.*, vol. 63, pt. 1, (1933).
3. Fermor, L. L.—Age of Aravalli Range. *Rec. Geol. Surv. Ind.*, vol. 62, pt. 4, (1930).
4. Gupta, B. C.—The Geology of Central Mewar. *Mem. Geol. Surv. Ind.*, vol. 65, pt. 2, (1934).
5. Gupta, B. C. and Mukerjee, P. N.—Geology of Gujarat and Southern Rajputana (*in the press*).
6. Heron, A. M.—Geology of North-Eastern Rajputana and Adjacent Districts. *Mem. Geol. Surv. Ind.*, vol. 45, pt. 1, (1917).
7. Heron, A. M.—Biana-Lalsot Hills in Eastern Rajputana. *Rec. Geol. Surv. Ind.*, vol. 48, pt. 4, (1917*a*).
8. Heron, A. M.—Gwalior and Vindhyan Systems in South-Eastern Rajputana. *Mem. Geol. Surv. Ind.*, vol. 45, pt. 2, (1922).
9. Heron, A. M.—Geology of Western Jaipur. *Rec. Geol. Surv. Ind.*, vol. 54, pt. 4, (1922*a*).
10. Heron, A. M.—Vindhyans of Western Rajputana. *Rec. Geol. Surv. Ind.*, vol. 55, pt. 4, (1933).
11. Heron, A. M.—Geology of South-eastern Mewar, Rajputana. *Mem. Geol. Surv. Ind.*, vol. 68, pt. 1, (1936).

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13. Heron, A. M. and Ghosh, P. K.—Geology of Palanpur, Danta and part of Idar States (*in the press*).
14. Krebs, N.—Morphologische Beobachtungen in Central India und Rajputana. *Zeits. der Gesellschaft für Erdkunde zu Berlin.*
15. La Touche, T. D.—Geology of Western Rajputana. *Mem. Geol. Surv. Ind.*, vol. 35, pt. 1, (1902).
16. Middlemiss, C. S.—Geology of Idar State. *Mem. Geol. Surv. Ind.*, vol. 44, pt. 1, (1921).

# SECTION OF BOTANY

*President* :—B. SAHNI, M.A., D.Sc., Sc.D., F.R.S.

# *Presidential Address*

## RECENT ADVANCES IN INDIAN PALÆOBOTANY.*

CONTENTS



* As this address was intended to be a helpful summary of recent work I have thought it useful to add what I believe is a complete, or nearly complete, bibliography of the works published since the subject was last reviewed in 1921 (see Sahni 1922). The text as here printed is also much fuller than the address actually read.

LADIES AND GENTLEMEN,

We are celebrating the Silver Jubilee of our Indian Science Congress in the presence of a galaxy of scientists from abroad. I am deeply sensible of the honour that has been done to me by the invitation to preside over the Section of Botany at this historic session.

Festive occasions often have a sad touch about them, and today we meet under the shadow of the death of two great men : Lord Rutherford, who was originally chosen to preside over us and Sir Jagadis Chandra Bose, the first amongst us to light the torch of science in this country. Let us honour their memory by standing in silence for a moment.

## INTRODUCTION.

About 12 years ago, when I had the honour of presiding over the Geology section, I said that fossil plants represent the debt that botany owes to geology.[80] And I then made an attempt to show how far we botanists can repay that debt by the study of fossil plants as an aid to geology. This morning I propose to take up the same theme. It was not till after the Great War that the study of fossil plants was revived in India, through a branch of the Cambridge school inspired by that doyen of palæobotanists, Professor Sir Albert Seward.[134] This revival we may date from our Calcutta meeting of 1921 [75] and it is gratifying to feel that in the meantime the field of palæobotany has become a happy meeting ground for botanists and geologists in this country.

I think that for the purpose of my address this is a particularly auspicious occasion. For we are meeting again in Calcutta, where this Congress was born, and Calcutta is the home of our Geological Survey, under whose auspices were laid the foundations of palæobotany in India. With its large resources the Geological Survey has continued to add to the scientific treasures of the Indian Museum, and to guard with jealous care the many irreplaceable type-specimens placed in its charge, which are so indispensable to future generations of students.

The work of the last seventeen years on Indian fossil plants has marked an advance both from the botanical and the geological point of view.

To the botanist, recent explorations in the field, and even a revision of the old collections in museums, both in India and abroad, have revealed new forms of plant life, some of them of great interest, or have extended his knowledge of species hitherto obscure. While the strata hold endless promise of future discoveries, intensive work in the laboratory is helping towards a richer appreciation of what we already possessed. Knowing by experience that trivial points in the structure of plant-remains often yield valuable clues to identity, the palæobotanist has cultivated an eye for detail such as a Sherlock Holmes might envy. A minute comparison of detached fragments has thus enabled him to correlate them as parts of one and the same plant, and even to attempt a reconstruction of the plant as it probably appeared in life. The investigation of fossil cuticles and spores, often retrieved from specimens once abandoned as useless, has revised his ideas concerning the affinities of plants long known under misleading names. In clays and shales previously thought to be sterile the microscope has revealed a wealth of life in the form of pollen grains and other resistant parts of plants, which are often highly characteristic of genera and species. Lastly, the comprehensive revision of a whole group of plants has thrown light upon its distribution in Time and Space, its range in structure, its affinities and evolutionary tendencies, its reactions to a changing geological background.

**Botanical aspect**

I think I have said enough at least to indicate the scope of the recent work on Indian fossil plants so far as it concerns the student of botany. We may now refer briefly to the way in which this work has impinged upon the domain of geology.

To the geologist this work has not only been helpful in tackling problems of stratigraphical correlation, but has also thrown light upon questions of palæogeography, past climates and even earth movements, both of the vertical and of the horizontal type. At the same time it has had its importance in connexion with economic enquiries.

**Geological aspect**

Sometimes, as we shall see, the palæobotanist has arrived at conclusions regarding the ages of strata which were at variance with those long held by geologists, but which have ultimately been supported by a variety of independent data. In other cases the palæobotanist, working solely on his own evidence, has visualized certain features in the geography of the past, or has explained the geographical relations of extinct floras by postulating certain tectonic movements, and his views have found welcome confirmation in the light of geological facts.

To attempt on this occasion anything like a detailed review of the recent work is out of the question. All we can hope to do in the brief time at our disposal is to follow up a few selected

lines of advance. Incidentally we shall see that the botanical and the geological points of view are sometimes so intricately mixed up that a separate treatment is neither easy nor profitable.

## Early Palæozoic Floras.

**Possible discovery of Psilophytales in India.**

From a cursory review of our fossil floras [75], which I undertook in 1921, prior to a detailed study, it appeared that an important gap in our knowledge lay in the earliest plant bearing strata. This gap still remains, for we have no evidence from this country of that primitive race of land plants, the Psilophytales, which had an almost worldwide distribution during the Devonian period. But the position seems to have become rather more hopeful of late. Recent geological work in Kashmir and Hazara has shown that land conditions prevailed in this area during the Siluro-Devonian period, when the Psilophytales flourished in many parts of the world. We may therefore look forward to the discovery of this ancient flora in any brackish or fresh water deposits of this age that may be exposed in this region. Such a hope is justified by the recent discovery of this group in the Silurian rocks of Australia on the one side and of N.W. Europe on the other. Only a couple of years ago Prof. Halle described some Psilophytales from the Devonian of China. In the Ordovician and Silurian shales of Spiti (in the N.W. Himalayas) traces of plants were found a little over thirty years ago, but although several of them have the repeatedly forked habit of the Psilophytales, no sign of vascular tissues or of the large terminal sporangia with cutinized spores characteristic of this group has so far been discovered. A critical examination of the plant-bearing shales may yet reveal the existence of this ubiquitous group of plants in the Himalayan region.

In their uniform simplicity these ancient vascular plants almost touch the Thallophyte level, and we all know that they were at first actually taken for algæ. Their almost cosmopolitan distribution in such early rocks may seem to lend support to the idea that they arose simultaneously from aquatic ancestors in many far scattered parts of the world; but I think that such a view probably underrates the enormous period of time which these plants had at their disposal for dispersal through space. Although generally referred to a single phylum they are more probably a plexus of groups containing the roots of several lines of evolution. Evidently the origin of those two mysterious substances, lignin and cutin, which still distinguish vascular plants from their probable ancestors, the Algæ, is to be sought further back in the geological record than we had ever imagined.

### The Po Series of Spiti.

**Basal part, Lower Carboniferous: evidence of plant-fossils.**

The value of fossil plants as an index of geological age has been strikingly demonstrated in a recent revision of a small flora from Spiti.[20] The plants occur only in the basal part of the Po Series of strata, known as the Thabo stage. They include *Rhacopteris* and other plants characteristic of a period when a uniform type of vegetation appears to have flourished in the northern and southern hemispheres. Professor Zeiller of Paris had long ago compared this flora with Lower Carboniferous species from Europe on the one side and Australia on the other. But prominent geologists in India, Middlemiss, Hayden, Holland and others, classed the whole of the Po Series, including the plant-beds, as Middle Carboniferous.[42] I had myself accepted this view of the Geological Survey, till in 1929 Professor Gothan insisted that the plants definitely indicate a Lower Carboniferous age. Since then independent grounds have been advanced in support of the same conclusion.[15, 124b]

### The Glossopteris Flora.

Towards the end of the Carboniferous period an extensive glaciation in the southern hemisphere killed out most of the older vegetation, while the contemporary northern flora, familiar to us in the Coal Measures of Europe and North America, appears to have flourished in a tropical climate. In the wake of the climatic revolution in the south there appeared an almost entirely new type of vegetation, which is known as the *Glossopteris* flora, after its predominant genus.

The relatively small number of species in this flora, the scarcity of arboreous forms, and the presence of sharply marked growth rings in the few trees that are known, are all facts which support the idea of a relatively cold temperate climate,[132] though in the later stages (Barakar, Damuda) the climate must have been sufficiently warm to maintain a vegetation rich enough to yield thick seams of coal. In contrast, the northern coal-measure flora was much richer in species, and it included many arboreous forms, with poorly marked or no growth-rings. An interesting fact about the northern Lower Permian flora is the apparent abundance of tree-ferns (*Psaronius*, *Zygopteris*, *Asterochlæna*, *Tubicaulis*, *Grammatopteris*) which often possess a felt of adventitious aerial roots[95a, 95b]; and the fact that among these roots we frequently meet with evidence of rich epiphytic growths (especially of zygopterids upon *Psaronius* trunks)[88] reminds one of the tropical rain forests of the present day.

The *Glossopteris* flora has been discovered in such far scattered countries as India, Australia, South Africa, South America and Antarctica. Yet it is so uniform in its general

character and at the same time so distinct from nearly all the northern floras of the time, that it must have been evolved on a distinct continent. There is ample evidence that at this period of the earth's history a great mediterranean ocean, the Tethys, separated the northern botanical provinces from a southern continent, of which India formed an integral part, its northern coast roughly following the trend-line of the present Himalayan Range. To this hypothetical southern continent geologists have given the name Gondwana Land.

It was in India that the first traces of the *Glossopteris* flora were discovered, now well over a hundred years ago; and it was here that the idea of a distinct southern continent first arose. Since then volumes have been written about Gondwana Land and its flora but it still intrigues us with its problems of geography and climate, and the distribution, affinities and geological relations of its flora. It still remains the centre of interest in Indian palæobotany.

### *Relation with the Carboniferous Ice Age.*

A much debated question is the exact relation of the Gondwana flora to the Ice Age from which it emerged. All the new geological data that have come to hand from Kashmir, the Salt Range and Central India are consistent with the old view (which fits in with the palæobotanical facts) that India was under ice during the Upper Carboniferous and in any case not later than the Lower Permian.[116] As regards the relations of the flora to the climate, we have long suspected that in India, as in South Africa, the *Glossopteris* flora had already come in before the land was free of ice and that it even includes some hardy remnants of the pre-glacial vegetation.[80] It is difficult to visualize the extent to which such a widespread glaciation must have affected the pre-existing flora, but it can hardly have destroyed all traces of life over the whole of Gondwana Land. Nor was the whole of this enormous area under ice at one and the same time. Even in intensely glaciated regions today there are localized asylums with microclimates of their own, the importance of which in the survival of species through a glacial period has to be recognized[12, 132a, 139, 154, 155].

There is nothing inherently improbable in the idea that the early phases of the *Glossopteris* flora overlapped with the latter end of the glaciation. Even today a rich vegetation (though sometimes only an ephemeral one) is known to flourish in many parts of the world in the vicinity of glaciers and ice sheets. We see this in parts of Greenland,[128, 132] in Norway,[41] Novaya Zemlya,[139] New Zealand,[132] Alaska,[41] Chile[41] and, nearer home, in the Himalayas.

Coming after a great Ice Age, the *Glossopteris* flora was bound to be very distinct from the contemporary floras of the

northern hemisphere, and also from the pre-glacial vegetation in the south. But the source of origin of so many entirely new forms of life, both plants and animals, remains a mystery. They seem to appear simultaneously over the whole of Gondwana Land: in South America, South Africa, Australia, and Antarctica; also in India. They could scarcely have come from any other part of the world, there was hardly any country left for them to come from: unless it was some remote parts of the Antarctic continent itself, most of which is still beyond the reach of geological investigation. The only conclusion is that these new forms of life, which are so characteristic of Gondwana Land, must be essentially an indigenous product, that is, of southern origin. They appear to have evolved rapidly from the meagre flora and fauna which had survived the Ice Age. It would almost seem that exposure to the rigours of the climate had quickened the pace of evolution, as if by inducing saltations on a large scale: a sort of natural vernalisation, affecting not only the individual life-cycle, but the rate of evolution of species, possibly through aberrations in the nuclear cycle. A palæobotanist has perhaps no right to indulge in speculations in cytophysiology, but I am advised that the idea is not quite an absurd one. The only alternative would seem to be the spontaneous origin of a number of entirely new and independent lines of evolution.[129] One must admit that this idea of occasional snaps in the life-lines of the organic world seems almost forced upon us by great palæontological breaks such as that at the base of the Gondwanas. But it appears that during recent years considerable progress has been made in our knowledge of the effect of the environment upon the structure of the nucleus. While the extinction of individual lines of descent must be accepted as a settled fact, it may be that the climatic revolution, from which the *Glossopteris* flora emerged, itself supplies the clue to the apparently sudden arrival of so many new forms of life.

The *Glossopteris* flora must have had its roots somewhere in the past, and as I suggested several years ago,[80] at least some of the lines of descent can be traced back into the preglacial flora.

In connexion with the climatic relations of the *Glossopteris* flora a discovery of unusual interest has been made within the last few weeks at Kathwai, in the Salt Range. At a level only about 20–25 feet above the glacial bed, Mr. E. R. Gee had collected, a couple of years ago, a small flora including *Glossopteris*, *Gangamopteris* and other Lower Gondwana plants. Until recently we had thought this to be the earliest known Gondwana flora in India. By macerating bits of the carbonaceous shale Miss Virkki[141] of Lucknow obtained, among other things, a great variety of spores, some simple, others provided with wings. In all at least two dozen species of spores were recognized, and a fact of special interest was that some of them (figs. 1, 2) recalled a

two-winged pollen grain, *Pityosporites antarcticus*, which Professor Seward [127] had described in 1914 from a remote part of Gondwana Land, within a few degrees of the South Pole. Although badly preserved and more than once called into question this solitary Antarctic pollen grain has recently acquired a new interest. At first taken for a microspore of a pine or podocarp, it is now regarded as more probably belonging to *Glossopteris*,[131] a genus which is known from two localities in Antarctica. Similar spores have recently been found in association with *Glossopteris* in South Africa, and within the last few days Miss Virkki has discovered hundreds of 2-winged spores (figs. 3, 4) in a piece of shale from New South Wales crowded with leaves of *G. Browniana*.[142] So we now know spores of the same general type from such far scattered parts of Gondwana Land as India, Australia, Africa and Antarctica. The age of the Antarctic pollen grain is not definitely known : it may be much younger than the Salt Range spores ; but the resemblance is noteworthy.

Kathwai was evidently worthy of a special visit, to see if a still earlier flora than that discovered by Mr. Gee could not be found, and Miss Virkki's trouble was amply rewarded. From two new horizons only about 1½ feet and 4½ feet above the boulder bed, in the same geological section that Mr. Gee had examined, she obtained a further lot of spores, and some of these are identical with those associated with *Glossopteris* and *Gangamopteris* higher up in the section.

As a caution it must be stated that the exact height of these new horizons above the glacial bed is still somewhat in doubt : Mr. Wadia tells me that the basal zone above which the 1½ feet were measured is not the original boulder bed, but a resorted deposit of glacial débris overlying the true Talchir horizon. He adds, however, that the difference in age between the original moraine and the resorted deposit cannot have been considerable.

Now, the time interval represented by the overlying 1½ feet of sediments must have been so short that the lowermost of the spore-bearing horizons may be taken to be approximately of the same geological age as the glacial bed. And if some of the winged spores really belonged to *Glossopteris* or *Gangamopteris*, a possibility which, as we have seen, is well worth considering, it would mean that here, in the Salt Range, at least, the *Glossopteris* flora was practically contemporaneous with the Carboniferous Ice Age. To prove that the flora actually co-existed with the ice it only remains to demonstrate these spores within the glacial matrix itself, and I think the facts at hand fully justify the expectation that this will be done. An investigation of the spore content of the glacial matrix, not only in the Salt Range but in other parts of Gondwana Land, is thus full of interesting possibilities.

Another interesting fact is that among these forerunners of

the *Glossopteris* flora at Kathwai were also a large number of winged seeds or fruits, referable to the genus *Samaropsis*, whose parent plants are still unknown. Whether some of these spores and seeds actually belong to Glossopterids is still an open question, but the fact that a large proportion of them are winged is perhaps not altogether without significance: they were the flying harbingers of a new flora which probably invaded India before the land was free of ice.

It is only fair to say, however, that there is another way of looking at these facts. Dr. C. S. Fox,[15, 16] who has made a careful study of the Lower Gondwanas, believes that in India the *Glossopteris* flora came in long after the ice had disappeared: even if plant remains were to be found preserved within the boulder bed they would not indicate contemporaneity with the ice, because according to him these materials were old moraines, re-sorted and deposited by streams long after the glaciation had passed away.

I confess it is not easy to share this view. In Kashmir, where we witness the same sort of association of modern forests and glaciers, probably most of the moraines in which the trees are rooted have undergone re-sorting since they were first deposited by the receding glaciers of the Pleistocene. The time interval between the modern flora and the end of the Pleistocene is relatively so small that a similar difference in age would scarcely count in the geological time scale of the Permo-Carboniferous: after all, we have scarcely yet emerged from the Pleistocene Ice Age, even in India!

Quite apart from these climatic questions, intensive work on the spore content of rocks has its importance in other directions. To the palæobotanist, spores are often of great diagnostic value, and a single tiny fragment of shale may reveal a dozen species of a flora hitherto unsuspected. Although the parent plants of these spores may be unknown, and they may not all belong to a local flora, they all have the same value to the geologist who is interested in the correlation of strata in scattered parts of the world, or of seams within a single coalfield. In fact, the ease with which spores travel across space should make them particularly useful as zone fossils. Quite recently Dr. Erdtman[18a] has published an interesting account of a varied flora of spores recovered from the atmosphere over the Atlantic Ocean. He also refers[18b] to other literature on the subject of spore dispersal. The recent works of Naumova[58] and Luber[50], presented before the last Geological Congress at Moscow, are significant in this connexion. The microscopic investigation of Indian coals is still almost a virgin field, but its possibilities in Indian economic geology are evident from the recent work of Dr. A. K. Banerji.[1]

Modern mycologists in Europe, America and India are familiar with the way in which the spores of fungi travel for

hundreds of miles with the prevailing winds and carry plant disease to distant regions. We therefore need not be sceptic if a palæobotanist were to claim that two given fragments of rock from distant parts of the world are of the same geological age if they both show the same kinds of well-defined spore forms.

*Botanical affinities of the Glossopterids.*

We may now briefly consider some purely botanical aspects of the *Glossopteris* flora. If I may anticipate what I am going to say, recent work in India and elsewhere seems to bring this flora into the foreground of that old question, the origin of the flowering plants. We are still ignorant of the affinities of those large, simple, net-veined leaves, referred to *Glossopteris*, *Gangamopteris* and other genera, which formed the most distinctive feature of this widespread flora. We have long suspected that *Glossopteris* was not a fern but a seed-plant. Professor Walton [150] has shown that its rhizome contains bordered tracheids of the gymnosperm type. On the other hand the fact that the epidermis of *G. angustifolia* [76] resembled that of angiosperms suggests an examination of other species in which the cuticle is preserved.

Do the Glossopterids after all belong to that ancient southern stock from which the flowering plants are supposed to have arisen? They were certainly a virile race, for they not only dominated the southern flora but spread far and wide into the northern continent of Angara Land, where Zalessky [159, 160, 161] and others have recognized several types of leaves recalling familiar Gondwana forms. Harris has referred to *Glossopteris* a broad net-veined leaf from the Rhaetic of Greenland, and a similar leaf from the Mesozoic of China has been figured by Gothan and Sze under the name *Anthrophyopsis*. Then there is the widespread Jurassic plant *Sagenopteris*, formerly taken for a fern but now known to belong to a totally different group, the Caytoniales, possibly intermediate in position between the gymnosperms and angiosperms. [32, 33, 106]

*Sagenopteris*, by the way, or leaves strongly recalling *Sagenopteris*, have quite recently been recognized in our Rajmahal flora by Mr. Jacob [45] of Lucknow. If these leaves really belong to the same genus as those from the Jurassic of Yorkshire, this is the first discovery of Caytoniales in India. In the same flora Mr. A. R. Rao [57, 58] has found a large number of 2-winged pollen grains, and some of these again may possibly belong to Caytoniales, though this is still an open question. The spores are of at least two different kinds; one kind is contained in pollen sacs of the coniferous type, but others were found scattered in the rock matrix and their affinities are still unknown.

Now, the fact that both *Sagenopteris* and *Glossopteris* are closely associated with those peculiar double-winged pollen grains of the *Pityosporites* type, seems to lend significance to the

outward resemblance between these net-veined leaves, both of which, moreover, recall those of dicotyledons. At the same time we must exercise caution before accepting any real affinity between these two genera till we know more about their reproductive organs.

My object in mentioning these facts here is by no means to suggest that *Glossopteris* gives the clue to the origin of angiosperms, but only to show how this question tends to get pushed further and further back in the geological scale. Not so long ago, the earliest undoubted angiosperms known to us were from the Lower Cretaceous rocks ; but structurally they were already so highly evolved that it was obvious the group must have had an origin long before the Cretaceous. Various discoveries before and since have suggested that angiosperms already existed in the Jurassic period. It is true that the Caytoniales, once claimed as true angiosperms, now appear in a different light.[32, 33] But we at least seem to have here, in this Jurassic group, an inkling of one of the ways in which the closed ovary may have originated.[106, 119] And if *Sagenopteris* was related to *Glossopteris*, which is pre-eminently a Palæozoic genus now generally regarded as a Pteridosperm, we can imagine the trend line of evolution traced back into one of the earliest groups of seed plants that we know.

I confess I do not yet see my own way clear. In dealing with such highly theoretical questions caution is necessary at every step. For, if palæobotany teaches us one thing more forcibly than any other, it is the wisdom of the open mind. Latterly some of us have been more impressed than ever with the older theory that the angiosperms arose from the Bennettitales or some closely allied group.[92, 104] But of this we shall have more to say at a later stage.

Botanists have long been familiar with the anatomy of many members of the coal-measure floras of Europe and North America, preserved in coal-balls. In the contemporary Lower Gondwana flora, almost the only known petrifactions belong to the artificial genus *Dadoxylon*. A sideritic block from the Parbelia Colliery in Bengal recently described by Mr. H. S. Rao[60] shows the nearest approach to a coal-ball yet discovered in Gondwana Land. It raises hopes of further discoveries which may yield data concerning the anatomy of some of the characteristic members of this flora.

### *Relation with the Palæozoic Angara flora.*

About 14 years ago several large petrified trees were unearthed near Asansol[78]: they all seem to belong to one species, *D. Zalesskyi*,[91] which shows a few interesting points of resemblance with the Siberian form *Mesopitys Tchihatcheffi*. This resemblance of a Gondwana plant with a member of the northern

flora is not an isolated fact. In the Palæozoic flora of Siberia the existence of a gondwana element has long been suspected. Although the occurrence of *Glossopteris* and *Gangamopteris* has been disputed *, and the gondwana affinities of the northern flora may have been over-estimated, some degree of affinity is generally admitted, and it demands explanation because the barrier of the Tethys sea separated the two botanical provinces. In order to explain this affinity palæobotanists have long believed that some means of communication for land plants must have existed across the sea. Among others, Professor Zalessky [159] insisted that either the marine barrier was bridged over by an isthmus or a dense archipelogo must have served as stepping stones for Gondwana plants migrating to the north. This supposition, it must be noted, was made 20 years ago, solely as an inference from the palæobotanical facts.' Since then the independent field work of Mr. Wadia in Kashmir and of Professor Mushketov † north of the Pamir plateau has proved that during Late Palæozoic times there was actually a series of land patches dotted over the Tethys sea in this region. These islands may well have served as a means of intermigration between the two floras.[112]

Field work by members of the Geological Survey of India in Kashmir on the one side and in N.E. Assam on the other has helped to define somewhat more precisely than before the northern coastline of the old Gondwana continent. Recent work has shown that the edge of Gondwana Land in this region, roughly parallel to the main Himalayan arc, was upheaved with the late Tertiary mountain building movements. Near Gulmarg in Kashmir, the highly tilted *Gangamopteris* beds, exposed at an altitude of about 13,600 feet, are probably the most elevated Gondwana plant beds known. The fact that Kashmir lay on the main route of migration between the Gondwana and Angara continents invests the flora of this region with special interest: and this flora, as suggested several years ago,[80] shows a somewhat closer affinity with the Siberian flora than does that of the peninsular Gondwanas.

### *Relation with theories of continental drift.*

Let us now turn to another aspect of palæobotany as an aid to geology: I mean the relation of palæobotany to certain theories of earth movements, particularly large horizontal movements

* Quite recently Professor Zalessky has described further specimens from Russia which he definitely assigns to these two genera.[160, 161]

† I wish to record my sincere thanks to Professor D. Mushketov for an interesting letter (14th January, 1937) in which (in reply to an enquiry) he drew my attention to his work of 1928 in Eastern Ferghana. Between the meridians of 70° and 75°E. he found evidence of many isolated dome-like elevations, only 10 to 50 miles apart, which would presumably suffice to account for the suggested migration.

of the continental type. Not very long ago geologists favoured the idea that a great portion of the old Gondwana continent was lost in the sea through the foundering of extensive land bridges. This idea is by no means obsolete now, but it no longer seems to have the same hold as it did even ten years ago. Data from several directions seem to be converging to the bold hypothesis, with which the name of Alfred Wegener is more closely associated than any other, that India and the southern land blocks were once directly connected together, and have since drifted apart, somewhat like the fragments of a disrupted iceberg. This view does not necessarily preclude the idea that the marginal portions of some of these continents may have been lost through block faulting.

A bird's-eye view of the four great Permocarboniferous floras does indeed seem to support the drift theory on common-sense grounds.[102, 104a, 105] Thus the familiar Coal Measure flora of Europe and North America lies sundered by the North Atlantic Ocean. The *Gigantopteris* flora of China and Western North America seems as if it was split in two by the Pacific. The *Glossopteris* flora lies in far scattered lands in the southern hemisphere; but curiously enough, its Indian section seems to have been pushed far up into the north, and is dovetailed in a most puzzling manner with the *Gigantopteris* flora of China, which has very little in common with it. Lastly, in Kashmir the *Glossopteris* flora reaches to within a few degrees of the Angara flora in Russia, which is also on the whole distinct from it, although at the same time it shows some undoubted Gondwana affinities.

I would hardly be justified, even if I had the time, to venture upon a discussion of Wegener's theory except in so far as it concerns the geographical position of India. The late Professor Wegener was mainly concerned with movements which involved a *drifting apart* of continental blocks. I shall deal briefly with what may be regarded as a complementary counterpart of Wegener's theory: a *drifting together* of continents once far separated by the ocean.[105, 107, 114]

According to Wegener India during the time of the Gondwana glaciation lay far to the south, next to Madagascar, wedged in between Africa on the one side and Australia on the other. Since then it is supposed to have drifted to its present position north of the Equator, so as to bring the Gondwanas to within a few degrees south of the Angara flora. We have just seen, too, that between these two floras there are some elements in common; and these appear to have crossed the ocean barrier by means of an archipelago, of which geological evidence exists. At first sight, therefore, the relations between the two botanical provinces seem to be easily and satisfactorily explained.

The matter is, however, not quite a simple one. Professor Halle[31] has raised the pertinent objection that if during the Permian period India lay near Madagascar, while Siberia was near

the Permian equator,the distance between the two regions would probably have been too great to be easily explained by migration across an archipelago, particularly as the two floras would in that case have been in such different climatic zones that effective migration is difficult to imagine. These difficulties are no doubt serious if they are based upon correct premises. But we are not bound to accept the details of Wegener's reconstruction of Pangæa. Towards the end of the Permian, when the disruption was well on the way, the distance between the two floras may have been much shorter than during the glaciation.

Another objection, and one that at first appeared a more serious one, is based on the work of geologists and oceanographers who have investigated the Arabian Sea and the structure of its coastline. The recent John Murray Expedition, led by Colonel Sewell,[156] found evidence which, it was suspected, might go to prove that this sea covers a foundered land-bridge once connecting India with Arabia and Somaliland. The simple coastline of the Arabian Sea coast, among other facts, no doubt suggests block faulting on a large scale; and the idea of a sunken land-bridge seemed at first to be supported by the fact that specimens of basaltic rock had been dredged up from the bottom of the sea. But Dr. Wiseman [156a] reports that at least some of these samples of basalt from the Carlsberg Ridge differ chemically from the Deccan traps and from other plateau basalts: 'there is strong evidence that they are of submarine origin and do not represent sunken remnants of any former land area'.

The true value of the accumulated data has still to be assessed. At the same time, as we shall see presently, the history of the Arabian Sea, as revealed by these investigations, contains nothing that is inconsistent with Wegener's main idea of the northward drift of India. The faulting just referred to was probably due to forces connected with the Late Tertiary movements that resulted in the uplift of the Himalayas. It therefore does not come into the evidence concerning the much earlier history of Gondwana Land. It probably indicates that a much larger block than merely the Indian peninsula was involved in the northward drift. Nor is it necessary to assume with Wegener that India originally lay quite so far south as Madagascar.

The net result is that you cannot get away altogether from the idea of continental drift, although you may have to couple it locally with the idea of the submergence of large tracts of land through faulting.

But with all this we cannot claim that the problem of the southern element in the Siberian flora is settled. The final solution lies in the lap of the future. Professor Jongmans is even prepared to believe that the gondwanoid forms in the Siberian flora arose independently in the northern continent.

But parallel evolution on such a large scale scarcely seems credible.

Professor Halle [31] is probably right that the Gondwana affinities of the Angara flora are not so close as was originally claimed. Some day, let us hope in the near future, a critical comparison of the two floras will show these affinities at their true value. But, in any case, even Professor Halle does not deny that the resemblances are there and that they demand explanation. At the present moment the only explanation seems to be that some means of communication across the Tethys must have enabled the two floras to intermigrate. The Gondwana flora of Kashmir which probably lay across this route of migration thus acquires a special importance from our present point of view. The migration theory at least has the merit that it was in the field long before Mushketov and Wadia brought forward geological facts in support of it. The Late Palæozoic archipelago across the Tethys, between India and Siberia, which Zalessky [159] postulated in 1918, may therefore well be claimed as a geological prophesy based on purely palæobotanical grounds.

I should now like to place before you another instance in which speculations based solely on palæobotanical grounds have found confirmation at the hands of geologists and have thrown light upon phenomena of tectonics, palæogeography and ancient climates.

Already in 1927 Professor Halle [30] had noticed the peculiar geographical relations between the *Glossopteris* flora of India and the Far Eastern *Gigantopteris* flora which extends as far south as Sumatra, like a wedge driven into Gondwana Land from the north. He acutely remarked that this 'abnormal north-south direction of the boundary line between the two floral regions . . . . . . . . may be found to be in some way connected with the tectonic features'. And he added that 'in the first place one might think of a connection between the eastern part of the Himalayan geosyncline and the sea in the region of the present Bay of Bengal'. Now, on a variety of grounds which we need not repeat here, the *Glossopteris* flora is generally regarded as a cold temperate flora,[132] while the *Gigantopteris* flora, like the closely allied coal measure flora of Europe, is believed to have flourished in a moist tropical climate. We know of no other two other floras, living or extinct, which are floristically and climatically so distinct, and yet lie thus side by side on the map: crossing the same latitudes along a north-south front of well nigh two thousand miles. East of the Sumatra wedge the trend of the boundary between the two floras is still obscure: if the reported occurrence of *Glossopteris* in N.W. Borneo is confirmed the boundary here turns sharply to the N.E. between Borneo and Siam; if not, it either sweeps eastwards [105, 107], generally following the line of the Malayan arc, and possibly extending as far as New Guinea; or, as Professor Jongmans

(1937, p. 361) * has recently suggested, it crosses Borneo in a S.W.-N.E. direction.[46a]

These peculiar geographical relations first came into full evidence when it was discovered that the essentially northern *Gigantopteris* flora extended as far south as Central Sumatra, just across the present Equator, as if cutting the *Glossopteris* province of Indo-Australia into two.

Here, then was a plantgeographical problem of the first magnitude. Whether this southern *Gigantopteris* salient was a broad sweeping arc or a sharp wedge, there was no doubt of a most unusual dovetailing of the two floras which was difficult to reconcile with the sharp contrasts between them. The palæobotanist saw no possible explanation of the phenomenon unless he made a series of large geological assumptions. These assumptions were, firstly, that the two land areas on which these very distinct floras were evolved were originally far apart, with a barrier between them effective enough to prevent any large intermingling of land plants: and such a barrier could only be a wide ocean; secondly, that the two provinces then lay in very different climatic zones of the globe: in other words, that the ocean barrier ran more or less in an east-west direction, unlike the present north-south boundary between the two regions; thirdly, that the two land masses drifted towards each other, respectively to the north and south, so as to narrow down the intervening barrier; fourthly, that owing to resistance offered by the sharp promontory of Gondwana Land in N.E. Assam, the free Far Eastern limb of the *Gigantopteris* province assumed a flanking movement round that angle; fifthly, that there may be a structural geological continuity of the mountain ranges round the Assam salient, that is, a syntaxial angle essentially of the same sort as Mr. Wadia [144] had already shown to exist round the N.W. promontory in Kashmir.

It was only natural to relate the latter phases of these horizontal movements with the vertical movements which resulted in the formation of the mountain ranges of northern India and Burma, roughly marking the old Gondwana coastline in this region. And if these upheavals resulted from one and the same series of orogenic forces, even though at slightly different times in India and Burma, it was rational to define the Himalayas so as to include not only the two limbs of the re-entrant angle in Kashmir, but the whole series of festoon-like loops of mountains

* Professor Jongmans (1937, fig. 2) reproduces in a revised form a map which I had published in 1935; but as I then suggested the exact position of the boundary in this region must depend upon more definite data. I am not aware, for example, that the S.E. portion of Borneo, which Professor Jongmans definitely includes in Gondwanaland, has yielded evidence of a *Glossopteris* flora or other data pointing to Gondwana conditions.

from our N.W. Frontier, possibly even Baluchistan as far as the Malay Archipelago.[105, 107, 114]

In connection with the suggested flanking movement of the *Gigantopteris* province round the pivot of the Assam promontory, the fan-like radiating drainage of S.E. Asia, with so many large rivers bunched together opposite the N.E. corner of Assam, appeared to assume a peculiar significance. It seemed as if this movement at least fitted in better with that ingenious modification of Wegener's drift theory, namely Gutenberg's idea of continental spreading.[28, 29] Indeed, according to Professor Kenneth Mason most of the rivers in that difficult region of deep gorges are probably true strike rivers, and Mr. Evans's [14] recent geological work has shown that this is a region of intense compression ; also that there is an actual geological continuity in the mountains round the Assam angle, such as we had already postulated.

It is difficult on this occasion to dwell longer on this fascinating subject, which is of interest alike to the botanist, the geologist and the geographer. Suffice it to say that to those palæobotanists who had something to do with the elaboration of these ideas it is a matter of some considerable satisfaction that on the whole their views have been found to fit in with the geological evidence. That some of these ideas had already occurred to geologists, notably to Mons. Fromaget,[18, 19] Director of the Geological Survey of Indo-China, only enhances the value of the independent palæobotanical evidence. It turned out, indeed, that some prominent geologists, Kropotkin and Gregory, Ting and Grabau,[140] as well as that well known botanical explorer, Capt. Kingdon Ward, had advocated views opposed to those suggested by the palæobotanical facts.[151, 152, 153] But the evidence subsequently adduced by Mr. Wadia,[147] Mr. Evans [14] and others has strongly upheld our conclusions.

Capt. Ward finds that the modern flora of the E. Himalayas is continued eastwards from Assam into the mountains of China, whereas the flora of the Arakan Yoma is different. This fact, among others, has led him to conclude that the Himalayas are continued eastwards across China, almost as far as the Pacific coast. But in the region of China where the supposed eastward continuation of the Himalayas would lie there is no evidence of any marine sediments of the Himalayan type. That region was a land area inhabited by the *Gigantopteris* flora. It is not surprising that the modern flora of the longitudinal range of mountains in Burma is different from that of the Assam Himalayas, for these lie on a different latitude and are subject to different meteorological influences.

If the history of this part of the earth's surface has been as I have just outlined, it will be clear that at least those parts of Burma lying east of the Arakan Yoma have no geological affinity with India. They have been brought into their present

position in comparatively recent times by horizontal forces which were ultimately responsible for the uplift of the Arakan Yoma.

### *Decline of the* Glossopteris *flora.*

*Parsora stage.* During the Permo-Triassic transition the *Glossopteris* flora suffered a decline, and in the Parsora beds in Rewah (Central India), which some geologists still prefer to class as the Middle Gondwanas,[143] a flora of a considerably younger aspect than that of the typical Lower Gondwanas has been collected. The main features of this flora are, firstly, the absence of most of the characteristic members of the *Glossopteris* flora, although at least a few of them, notably *Noeggerathiopsis Hislopi*, still survive, and secondly the abundance of forked leaves of the *Dicroidium* type. This is a widespread southern genus which in other parts of Gondwana Land is regarded as marking the Triassic period.

The age of the Parsora beds has been much disputed. In 1917 Dr. Cotter classed them as Rhaetic, and in 1921 I accepted this correlation.[75] In 1926 I was inclined to regard the flora as older, and provisionally referred it to the Upper Trias.[80] In 1932 Professor Seward, who examined a further collection from the same region, suggested that the flora was still older, at least as old as the Lower Trias and more probably Late Permian.[130] While palæobotanical opinion during the past two decades has thus tended to place the Parsora beds lower and lower in the geological scale, Dr. Fox,[15] in his recent important work on the Gondwana System, has placed them as high as the Jurassic; he regards them as only slightly older than the Rajmahal series.

The whole question is still open, because some recent collections added by Mr. N. K. N. Aiyengar and by Mr. S. D. Saksena still await examination. Dr. Fox is probably right that in Dr. Cotter's list of this flora, which I had accepted on his authority, species from two distinct horizons were mixed up. But even after allowing for this, and considering only the specimens from Parsora, Chicharia and other northern localities which Dr. Fox assigns to the Upper Gondwana, the flora appears to me to be distinctly older than the Jurassic.

## MESOZOIC FLORAS.

We have already seen that Eastern Burma was probably not a part of Gondwana Land. This being the case, it is to be expected that the fossil floras of that region would be more akin to those of the Far East than to those of India. From the Loi-an series of beds in the Southern Shan States, adjoining China, a Rhaetic or Jurassic flora chiefly comprising of ferns and conifers has been collected. Only the conifers [82, 89] have yet been examined,

and these on the whole seem to be allied to Chinese forms rather than to members of the Gondwana flora.

But we are now entering upon an era when the regional contrasts between floras were again breaking down. Indeed the flora of the Jurassic period includes so many species which apparently had a worldwide distribution that the problem is how this fact is to be explained if the earth was divided then, as it is now, into distinct climatic zones. The same question applies to the 'cosmopolitan' floras of the Devonian and early Carboniferous periods. The Jurassic flora of Graham Land, far away in the southern hemisphere, on the edge of Antarctica, seems to be more nearly allied to that of our Rajmahal Hills in Behar than to any other known flora of that age; and the Rajmahal flora in turn includes a number of species closely resembling Jurassic plants from England and Scotland. A small flora from Afghan-Turkistan, now being described by Mr. Sitholey,[135] includes some forms allied to Jurassic plants from Angaraland, and others recalling species form the Upper Gondwanas.

Whether any theory of continental drift will ever help to solve this problem of 'cosmopolitan' floras it is too early yet to say. Perhaps some day we shall have enough data to be able to correlate at least the major climatic oscillations in geological time with large geographical changes possibly due to drifts connected with a shifting of the earth's axis. This may give the clue to some of the anomalies of the distribution of extinct floras which puzzle us today. But such an attempt here would lead us too far into speculation.

### *The flora of the Rajmahal Series.*

I shall now devote a few words to the progress made in recent years in our knowledge of the Indian Jurassic floras, particularly that of the Rajmahal Hills. This was the first Indian flora to be described in any detail, and it is a classical flora because it has served as a basis for botanical comparisons and geological correlation for many allied floras in other parts of the world. It is therefore important to define as precisely as possible the structure and affinities of the plants, as well as the geological age of the plant-bearing beds, which are exposed in numerous places scattered over an area of nearly 4,000 square miles.

### *Silicified plants from the Rajmahal Hills.*

Until recent years our knowledge of this flora, like that of most others of the same age, was practically confined to leaf impressions, and no fresh collections had been reported since Feistmantel described the flora over half century ago. Latterly

the Rajmahal Hills have received a good deal of attention.[55-58, 90, 92, 103, 117–119, 137, 138] Many new plant-bearing localities have been found and large collections have been added.[26] An event of special importance to palæobotanists is the discovery of several localities which have yielded abundant silicified remains. This has already enabled us to study the anatomy of familiar members of the Rajmahal flora such as *Tæniopteris*, *Ptilophyllum*, *Williamsonia* and others. It has helped us at least partly to meet two of the main difficulties with which the student of fossil plants has to contend, namely, the fragmentary nature of the material and the fact that it too often consists only of impressions, which are notoriously unreliable as guides to affinity. These petrifactions, moreover, have made it possible to recognize, as parts of one and the same plant, leaves, stems, flowers and other detached organs which have long been under distinct generic names.

As one instance I may mention the leaf impressions to which McClelland, I think in the very first annual report of the Geological Survey of India, as long ago as 1850, gave the name *Taeniopteris spatulata*. In the midrib of these leaves, now available in the petrified state, a series of mesarch bundles of the modern Cycadean type were noticed a few years ago (fig. 5).[93] A detailed investigation of the material was entrusted to Mr. A. R. Rao,[55, 56] and his study of the epidermis opens up the question whether this plant, originally taken for a fern, was a true cycad, or one of the Bennettitales. In the same rocks occur a number of short shoots covered with rhomboid leaf scars, on which a horizontal row of 6 to 8 vascular bundles are marked. These shoots were previously mistaken for cones, but are now under suspicion as the parent axes on which the *Tæniopteris* leaves were attached. Similar shoots, now discovered in the petrified state, reveal a ring of five tangentially flattened bundles round a central pith ; these bundles give off multiple leaf-traces such as might well have supplied the expanded leaf base of a *Tæniopteris*. What is more, Mr. B. P. Srivastava [137, 138] has discovered in the same rocks a number of larger stems, referred by him to a new genus *Pentoxylon* ; and these also generally contain five tangentially flattened primary steles round a pith. In these thicker stems each primary stele has secondary wood all round, but this wood shows an unusual mode of development. It is enormously developed on the side turned towards the pith so that as the stem grows in age the five steles tend to grow mostly on their inner sides.

On the evidence before us we thus have strong grounds for the belief that the leaves, which have been known to palæobotanists for almost ninety years under the name *Tæniopteris spatulata*, were leaves of the deciduous type, borne upon short cylindrical shoots, and that these in turn were the younger branches of *Pentoxylon* stems. Now the wood of *Pentoxylon*, curiously enough, is of the compact, coniferous type, with narrow

medullary rays and bordered pits, so that if the correlations here suggested are well founded, we have an interesting combination of cycadean and coniferous features. At the same time the structure of the wood and the mode of branching of the steles recalls that seen in the problematical genus *Rhexoxylon* which is known from two distant regions, South Africa and Antarctica.

These facts will show how the discovery of these petrifactions has affected the original notions concerning the affinities of one of the first species of fossil plants ever described from this country. The true affinities can only be discussed when the reproductive organs are discovered, and it may well be that some seed bearing cones (*Conites Pascoei* Sahni [89], *Carnoconites* Srivastava [138]) which in places occur plentifully in association with the leaves, were the fructifications of *Pentoxylon.* It is not impossible that this interesting type will turn out to be a representative of an entirely new and synthetic group of plants combining cycadean, Bennettitalean, coniferous and other features. I must not further speculate upon the results of this work, in which Mr. Rao and Mr. Srivastava are still engaged at Lucknow, but enough has been said to show the far-reaching implications of the discovery of these petrifactions.

Let us consider one more example of a similar kind. Several years ago Professor Seward showed that the Bennettitalean leaves long known as *Ptilophyllum* cf. *cutchense*, previously only found detached, were borne upon stems of the type to which he had given the name *Bucklandia indica.* He surmised that the flowers of this plant were probably of the *Williamsonia* type, of which several species were already known from the Jurassic rocks of India though none of them had been found attached. Now, among the petrifactions recently discovered was a *Williamsonia* flower borne upon the tip of a short vegetative axis, and this axis agrees with *Bucklandia indica* in the anatomy of the wood and leaf bases. These facts have provided the main data for a reconstruction of what is now the most completely known of all Williamsonias, *Williamsonia Sewardiana.*[90] This flower, by the way, very closely resembles a species from the Jurassic of Scotland, described by Professor Seward as *W. scotica,* so that we have here a striking link between two geographically far separated floras.

A fragment of petrified wood, found long ago at an unknown spot in the Rajmahal Hills, has turned out to be a fossil of more than ordinary interest. It has been given the name *Homoxylon rajmahalense.*[92] The interest of this fossil lies in its anatomical resemblance with the wood of some fossil cycads on the one side and with that of some modern dicotyledons, referred to the primitive group of the Magnoliales, on the other. It thus seems to lend support to the idea that at least one line of angiosperms was derived from some gymnospermous group related to the Bennettitales.

*Homoxylon* was at first taken for a piece of conifer wood, because it was a homogeneous wood devoid of true vessels, the chief woody elements being tracheids. But the structure of the medullary rays was different, and the sculpturing of the secondary wood showed a range of variation, from the scalariform to the round bordered type, which was unknown in the conifers.[92, 104] These features were to be found only in two circles of affinity: firstly, in the Jurassic group of the Bennettitales which is strongly represented in our Rajmahal flora; and, secondly, in the living homoxylous genera *Drimys*, *Zygogynum*, *Trochodendron* and *Tentracentron*,[22, 23] which also have a primitive floral organization, recalling that of the Bennettitales. Soon afterwards a fossil wood *Tetracentronites*,[52] came to light from the mesozoic of Greenland and this, as the name implies, resembles the modern *Tetracentron*.[96] Whether *Homoxylon* was the wood of a primitive angiosperm or whether, as Dr. K. M. Gupta has suggested, it belonged after all to one of the Bennettitales—and this is a possibility always to be kept in mind—the theoretical interest of this solitary fragment of wood is obvious.

There is, of course, no suggestion of anything like a direct connexion between the modern Magnoliaceæ and the Bennettitales as we know them today. All that is implied is that in its descent the modern group seems more nearly related to the Bennettitalean line than to any other. Because latterly the structure of the epidermis has risen into prominence in phylogenetic studies, Mr. H. S. Rao[62] undertook at my suggestion to examine the epidermis of modern Magnoliales and particularly that of the homoxylous genera, and, as you will learn from himself today, although the Magnoliales as a whole seem to be a mixed group from the epidermal stand-point, all the homoxylous genera examined (*Trochodendron*, *Tetracentron* and *Drimys*) constantly show the same type of stomatal structure as that characteristic of the Bennettitales. On the whole, therefore, the evidence does not contradict the idea of a common origin for at least the homoxylous Magnoliales and the Bennettitales.

Among other Rajmahal petrifactions is a slender stem, (*Lycoxylon indicum* Srivastava [138]) containing a stele with 16 protoxylems placed at the ends of woody plates, exactly as in a modern *Lycopodium*. This may be the petrified form of *Lycopodites gracilis*, the surface impression of a shoot first described about 75 years ago. The silicified stems and petioles of several ferns have been discovered. One or two of these are attached to pinnæ, so it should be possible to correlate the anatomy with species known from impressions.

Among impressions newly discovered perhaps the most interesting is *Rajmahalia paradoxa*,[118, 119] a concave plate of rhomboid form bearing a mosaic pattern of scars, some rounded, others polygonal—suggesting that it is probably a new type of Bennettitalean flower. Some of the other fructifications recently

discovered in the Rajmahal Hills are *Ontheodendron*,[117] probably one of the Araucarineæ; *Nipaniostrobus* A. R. Rao,[58] a conifer having ovules with peculiar curved micropyles; *Masculostrobus rajmahalensis*,[58] a male cone containing two-winged pollen grains of the type familiar in pines and podocarps; *Sakristrobus*, a new genus of entirely unknown affinity, found by Mr. Jacob[45] in association with the *Sagenopteris*-like leaves already mentioned; and hundreds of seeds, probably of *Nilssonia*.

Time does not permit anything like an adequate summary of this work, which is still being carried on by Messrs. Srivastava, Gupta, A. R. Rao, Jacob and others. But enough has been said to indicate the significance of the results, achieved and expected, from an intensive examination of this rich flora, the only known Jurassic flora that has yielded so much information about its anatomy.

### *Age of the Indian Upper Gondwana floras.*

Before leaving the Rajmahal flora I should like to draw your attention to certain doubts that have recently arisen concerning the ages of our Upper Gondwana floras. The plant-bearing beds are exposed in far scattered areas. Apart from the Rajmahal Hills in Behar, they occur in Cutch and Kathiawar, in the Central Provinces, and in a string of outliers along the east coast, from Orissa as far as Ceylon.[133, 46] A few fossil plants of Upper Gondwana age occur also in the north, near Shekh Budin in the N.W. Frontier Province.

With the exception of the Rajmahal, none of these floras have yet been critically examined since they were first described, well over half a century ago. In their general composition, with a preponderance of ferns, cycads and conifers, and with not a single species characteristic of the Cretaceous, they all strike one, so far as we know them at present, as good Jurassic floras. At the same time we cannot yet say whether the sequence in which the Rajmahal, Kota, Jabalpur and Umia stages are generally placed by geologists is fully supported by the plant evidence.

The Rajmahal flora was originally placed by Feistmantel in the Lias, but in 1913 Professor Halle gave reasons for regarding it as Middle Jurassic. About eleven years ago Dr. du Toit suggested that the base of the Rajmahal series may possibly extend into the Rhaetic or even into the Keuper. On the other hand Dr. L. F. Spath,[136] on the evidence of some cephalopods in the Upper Gondwanas of the Madras coast, has not only assigned these beds to the Lower Cretaceous but concludes that all the Upper Gondwana beds of India are at least as young as the Lower Cretaceous.

If we are to take the plant-fossils as a guide, then at least so far as the Rajmahal flora is concerned, there does not seem to be much to say for the Cretaceous view. A species of *Proto-*

*cyathea*, recently described from the Sakrigali beds by Mr. Jacob,[44] may at first seem to indicate that here the series passes up into the Cretaceous. It is true this genus was not so far known in the Jurassic ; but it is only a form genus, based upon casts of the stems of tree-ferns. All it indicates is the occurrence of Cyatheaceous ferns with a large multiple leaf-trace. Leaf impressions referable to this family are already known in the Jurassic. Mr. Jacob's species, moreover, being new to science,cannot by itself serve as an index of geological age, and it is associated with typical Rajmahal species of cycads and conifers : *Ptilophyllum acutifolium*, *Nilssonia Morrisiana*, *Brachyphyllum expansum*, and other forms.

This is all that the plants have to offer in support of Dr. Spath's view, and you will agree this is not worth much. A point could perhaps be made for an Upper Jurassic age if we knew definitely that *Williamsonia scotica*, with which the Rajmahal form *W. Sewardiana* is closely allied, is definitely an Upper Jurassic species, but at present even this is uncertain. On the other hand, if the Rajmahal stems known as *Pentoxylon* have any real affinity with the genus *Rhexoxylon*, which again is uncertain, we may have some remote indication in favour of Dr. du Toit's view that the Rajmahal series may extend back into the Trias.

I am not competent to express an opinion on the nature of Dr. Spath's evidence from the Madras Ammonites, and how far it is justifiable to apply that evidence to other areas. But if that evidence is conclusive and if it must also apply to the Rajmahal beds, then here, at least, is a real bone of contention between the palæobotanist and the palæozoologist. We were so long accustomed to look upon the Rajmahal flora as Jurassic that we had nearly forgotten there was any other viewpoint but the palæobotanical. But I am one of those who believe that between the testimony of fossil plants and the testimony of fossil animals there is, and there ought to be, no real conflict. Nor do I believe that where the field relations of the beds are clear they should ever contradict the fossil evidence. Apparent contradictions there are many, as we shall see in our joint discussion [124a] on the subject this afternoon. But these contradictions, I venture to think, are nearly all of our own making. They are born of errors due to a lack of data or to our own imperfect understanding of the data.

As regards the floras of the Kota, Jabalpur and Umia stages, which are much less known, it would be rash to express definite views till our revision of these floras is finished. The Umia plant-beds were originally classed as Jurassic, and the flora did not seem to contradict this view. But some years ago we were told that these freshwater deposits are interstratified with marine fossiliferous beds homotaxial with the Wealden. If this is an established fact we must look for a Lower Cretaceous element in the flora. At the present moment no undoubted

Lower Cretaceous forms are known from these beds but some recent collections have not yet been examined.

*A Wealden flora in India.*

Quite recently Dr. Heron and Mr. P. N. Mukerjee have discovered what I believe is the only land flora in India definitely known to be of Cretaceous age. This comes from the Himmatnagar sandstone in the Idar State in Western Rajputana. In this small collection it was interesting to find two widespread genera of xerophytic ferns, *Matonidium* and *Weichselia,* showing for the first time the extension of the Wealden flora into India.[111] The *Matonidium* is a new species closely related to *M. Goepperti,* which is more common in the Wealden rocks than in the Jurassic. The other genus is represented by the well known form *W. reticulata,* a leading species of the Wealden flora. In the Nubian sandstone of Egypt this fern is associated with some undoubted dicotyledons. It would be interesting to look for the remains of flowering plants in the Himmatnagar sandstone, and for *Weichselia* in the Umia beds. It would be interesting also to know if the Barmer sandstone in Rajputana, in which angiosperms are known to occur, is of the same age as the Himmatnagar beds. The floras of the Bagh beds, and of the Lameta beds, which underlie the great Tertiary volcanic series in the Deccan, are still entirely unknown.

*Cretaceous marine algæ from Southern India.*

In the marine limestones of the Niniyur group in the Trichinopoly district Professor L. Rama Rao [64] of Bangalore discovered an algal flora of great interest, a description of which we owe to Professor Julius Pia. The plants have been referred to several existing families of sea weeds. The majority of the species being new to science the flora by itself does not throw much light upon the age of the limestones, but on the whole the evidence at hand suggests that these plants flourished in a transgression of the sea towards the close of the Cretaceous period.

## TERTIARY FLORAS.

*Tertiary (and ? post-Tertiary) algæ.*

So far as we know this is the first record of algal remains from the Cretaceous rocks of India. But in the early Tertiary beds, deposited along the shores of the great Nummulitic sea, we have evidence of marine or brackish-water algæ from a number of scattered localities. From the Ecoene of Sind Professor Walton [149] described a *Triploporella,* a member of the modern family Dasycladaceæ. From the Nummultic beds of Cherrapunji in Assam the late Professor H. C. Das-Gupta [6] assigned

to *Lithothamnium* some algæ associated with diatoms and Foraminifera. The reference to the modern genus should be regarded as provisional. He also mentions the occurrence of similar algæ in Navanagar, Porbunder and elsewhere in Western India, in rocks apparently of much younger ages. A further collection from Assam, recently sent me by the Director of the Geological Survey, seems to include a calcareous algal flora comparable in importance with that discovered by Professor Rama Rao in Southern India. Fossil algæ have also been found in strata of debatable age in Waziristan and in the Kohat district on the N.W. Frontier.

Characeous fruits, often loosely described under the modern genus *Chara*, but more safely assigned to *Gyrogonites*, were first reported from Tertiary beds in the Deccan just over a hundred years ago,[51, 8] but they have never been adequately described. In recent years they have been collected in several new localities, notably near Sausar in the Chhindwara district,[99] and again in the Rajahmundry area.[66] In the latter district (near Pungadi and Dudukur) the Mysore geologists Narayana Rao and Sripada Rao have discovered several genera of marine algæ, including *Acicularia*, *Neomeris* and, strangely enough, a *Holosporella* [68] apparently identical with an Upper Triassic species from the Burmo-Siamese border.

Evidently, the algal remains of the Indian strata offer a vast field of research, of which only the fringe has yet been touched. It is not improbable that their investigation will yield results of importance both to the botanist and the stratigraphical geologist.

### *The flora of the Deccan Intertrappean Series.*

During the times when these algæ flourished in the estuarine and coastal waters of the Deccan, the peninsula witnessed an era of unprecedented volcanic activity. Lavas of a fluid type welled up from fissures in the earth and overflowed the land, while rains of volcanic ash repeatedly overwhelmed the vegetation.

An observant traveller landing at Bombay, who crosses the Western Ghats by the Great Indian Peninsular railway, cannot fail to notice the low, flat-topped hills which dominate the landscape as far as Nagpur and beyond. These terraces represent the weathered surfaces of these lava flows or ' traps ' at different levels in a great basaltic series, aggregating several thousand feet in thickness. Here and there, between the traps, are preserved lenticles of freshwater sediments, occasionally mixed with beds of volcanic ash. These so-called Intertrappean deposits appear to have been mostly laid down in small temporary lakes which must have been formed at intervals by the damming up of streams by intermittent outbursts of lava; and they contain a most valuable record of the floras and faunas of those times.

The Intertrappean flora is indeed one of unique interest, because nearly all the major groups of the plant kingdom are represented, and the plants are mostly silicified, their structure being often exquisitely preserved. It is therefore worth while to devote a few words to an account of this important flora, and of the way in which it has influenced the views of geologists concerning the age of the Deccan lavas.

**Age, early Tertiary: decisive evidence of plants.**

Interest in the geology and palæontology of the Deccan dates back through well over a hundred years. It is associated with the names of some of the earliest geologists who worked in this country: Malcolmson,[51] Hislop and Hunter,[38–40] Carter [3] and others. Of the large collection of fossils that we owe to the labours of these pioneers, the animals have been described, but the plant remains were never adequately examined. For over 70 years they were forgotten, scattered in various museums in India and abroad. Many of these historic specimens, alas, can no longer be traced and are apparently lost to science. The long years of oblivion suffered by these collections were particularly unfortunate, because the clear and direct evidence of the age of the Deccan Traps, which this flora provides, was temporarily lost sight of. This evidence was in their time appreciated by Malcolmson, Hislop and others, who compared the flora in a general way with that of the London Clay, already known from Bowerbank's work.[2] Down to 1871 Thomas Oldham [54] also upheld the view that the Traps were of early Tertiary age. But soon afterwards serious doubts arose among geologists as to the wisdom of relying upon fossil plants in fixing the ages of strata. A prolonged and bitter controversy over the ages of the Gondwana floras resulted in a serious setback to the recognition of palæobotany as an aid to stratigraphical geology. For the time being, at any rate, fossil plants were at a discount, not only here but in Europe.

In India the effect of this opposition was particularly severe: the foremost Indian geologists of the day, including such influential men as W. T. Blanford, H. B. Medlicott and the Oldhams, had given the verdict that the evidence of plant-remains was untrustworthy: the palæobotanical witness had to stand down.

It was during this period that the question of the age of the Deccan Traps was reviewed, more than once. The animal evidence, at first thought to support a Tertiary age, now appeared to give no lead in the matter. And the plants, of course, were not to be trusted. There remained only the indirect evidence, firstly, of the underlying Lameta beds whose exact relations with the Traps, by the way, are still unknown; and, secondly, of conditions in other areas, like the West Coast at Surat and Broach and even further afield, in Sind and Baluchistan. Relying upon these data for what they were worth, W. T. Blanford (see under 5) cast his opinion in favour of the view that the Deccan

lavas were of Cretaceous age, not Tertiary as the plants had suggested. Whether it was that this indirect evidence was really decisive or whether the Gondwana controversy had turned him against the plants, the fact remains that the Cretaceous view prevailed. Blanford certainly had not much respect for plant-remains. But his judgment in most debated questions was reputed to be so sound that I reckon this was one of the few matters in which he erred. Thirty years ago Sir Arthur Smith Woodward [158] reiterated the old view, this time on the basis of some fish remains from beds then believed to be Lametas but which quite probably were Intertrappeans. But the verdict had been given, and Blanford's view held almost undisputed sway [42, 143] until—shall we say, *the plants came into the evidence once more*. This happened in January 1934, when a preliminary account of the Deccan flora was placed before this section at the Bombay session of the Congress.[98, 99, 100, 120, 123]

Enquiries made during the previous seven or eight years had already led to the recovery of many of the old specimens from various museums both in India and elsewhere. At the same time, fresh collections had been added from a number of new localities by members of the Geological Survey, by Professors Rode, Agharkar and Parija, by Mr. Shukla of Nagpur and by others. Of the new discoveries the most important from the point of view of geological age was Professor Rode's find of an undoubted *Nipadites*, [70, 121] a genus of palm fruits eminently characteristic of the Eocene (fig. 9). Its value lay in the fact that although Hislop [38, 40, 3] had mentioned this genus among his large collection of fruits and seeds, the original specimens had never been described and were no longer traceable.

The detailed investigation of this accumulated material, now being described at Lucknow, will take some time but, as explained, our preliminary survey had already made it clear some years ago that a flora which included *Nipadites*, the familiar water-fern *Azolla*, and, especially, an overwhelming proportion of palms, could not have flourished in Cretaceous times: it was undoubtedly a younger flora.

But this was by no means all. Soon after the first reaction of scepticism [17] was over, fresh evidence from a number of different sources converged in support of a Tertiary age. Messrs. Narayana Rao and Sripada Rao [66] of Mysore announced that in the basal Intertrappeans near Rajahmundry they had discovered the remains of the sea-weed *Acicularia*, essentially a Tertiary genus, as well as several species of stoneworts which they identified with well known Tertiary forms from Europe. Professor L. Rama Rao [63, 65] of Bangalore reviewed the question as a geologist and on the whole favoured the view that 'the Tertiary era had already dawned when the first lavas of the Deccan were poured out'. From the animal side, too, the evidence became reassuring. Professor J. H. Bonnema of Groningen, who kindly examined some ostracod

remains at my request, was of the opinion that although their testimony was not decisive, they were more probably Tertiary than Cretaceous. The most encouraging results have accrued from Dr. Hora's examination of the fish-remains,[43] which not only confirmed the plant evidence as to the age, but also supported the idea, suggested by the occurrence of *Nipadites*, and at first received with scepticism by Mr. Crookshank, that at least in some parts of the Central Provinces estuarine conditions must have prevailed. Lastly, Professor V. S. Dubey [11] of Benares wrote that his estimates of the helium content, at least of the basalts in Western India, also indicated a Tertiary age; although, of course, the traps round Nagpur, Chhindwara and Rajahmundry should also be estimated before the evidence from radioactivity can be said to prove that the whole of the Trap series is of post-Cretaceous age. The reason for this caution is that it was from these areas that the fossil evidence was derived, and it is here that the earliest traps are said to be exposed.

Taken as a whole, the evidence was distinctly in favour of the conclusion based upon the plant remains.[5, 67, 115]

Happily, the controversy is now almost laid at rest. Last year, when this question was discussed at our Hyderabad session, we had the gratification to find that some geologists took the lead in upholding the view which had so long remained in the background. In short, we discovered on that occasion, as we have done before and since, that there really is no conflict between the testimony of the rocks and that of the plants or of the animals.

I have gone into the history of this question in some detail—in greater detail, perhaps, than is appropriate to an address—but I thought that no review of palæobotany in India would be complete without a reference to the way in which the study of plant-remains has come into its own. But of this we shall hear more at the discussion on plant and animal fossils which is to come off this afternoon.

Botanical interest of this flora.

Of individual plants of botanical interest in the Deccan flora the number is too large to justify more than a cursory reference. At least in some localities the flora is largely an aquatic one, and, as stated, local estuarine conditions are indicated by the occurrence of *Nipadites*, a fruit closely resembling that of the stemless palm *Nipa fruitcans* which is common in the Sunderbans and other tropical estuaries at the present day. Other palm fruits include one with a trilocular ovary and three large seeds, the fibrous fruit-coat being traversed by longitudinal canals which must have aided dispersal in water.[69, 100, 121] Some of the algæ, as we have seen, were brackish-water or even marine forms. Other aquatic plants are represented by abundant fruits of Charophyta, angiosperm stems with large air-channels and poorly developed wood, shreds of ærenchymatous tissue in the

process of decay, associated with fungal mycelia as well as filamentous aquatic algæ apparently covered with minute unicellular epiphytes. Specially interesting, and very common at Sausar, is an *Azolla* [120, 61] whose mega- and microsporocarps, and many free-lying massulæ with their anchor-tipped glochidia, are perfectly preserved ; fragments of leaves and stems, as well as roots covered with root-sheaths, within which a row of papillæ apparently represent young root hairs, can be matched with the corresponding organs of some living species of this water-fern. The name *Enigmocarpon* has been given to a multilocular fruit (fig. 14) of unknown affinity ; [70, 100, 121] it has eight radial septa springing from an axile placenta ; the thick carpel wall consists of spongy tissue well adapted for dispersal by water ; the dehiscence is clearly marked as loculicidal ; the numerous anatropous ovules contain a dicotyledonous embryo. Two species of cardamoms were found (one is shown in figs. 6, 7), and a strange kind of longitudinally ribbed seed has been given the name *Sausarospermum*.[123] *Viracarpon* [100] is a cylindrical aggregate fruit with six-seeded partial fruits crowded round the axis. Two new genera of seed bearing cones,[89] *Takliostrobus* and *Indostrobus*, as well as a new species referred to *Pityostrobus*,[89] show that the conifers were not unrepresented. Dicotyledons are also to be found.[71–72] But by far the commonest plant-remains in this prolific flora are the petrified stems of palms,[87] sometimes with their sheathing leaf bases attached, and often with a mantle of adventitious roots still preserved round the base of the trunk.

Unfortunately, these fragments of palm stems are never found in organic connexion with flowers or fruits, or even with the distal parts of leaves, which might give some clue to their systematic position in the family, for there must be many genera and several tribes of this family represented among the hundreds of specimens collected. In the absence of satisfactory criteria for a natural classification palæobotanists have been forced to group all species of petrified palm wood into the single artificial genus *Palmoxylon*. Of this genus we have now been able to put together, in the course of the last 17 years' work, no less than 45 Indian species,[87, 94, 69, 74] where only three were known before, including one from Ceylon.

The variety of structure shown by these *Palmoxyla* is bewildering. A highly artificial classification, based upon variable features of the anatomy, such as the distribution and form of the fibrovascular bundles, has been adopted, and the danger of creating spurious species is enhanced by the fact that these characters vary in different parts of the same stem.

Obviously, in describing these Indian *Palmoxyla* it was important to compare the anatomy of modern species of palms, with a view to discover, if possible, some more constant and reliable criteria of affinity. There was always the hope that in this way we might be able to link up at least some of the fossil

species with modern genera whose place in the family was established on the safer ground of floral structure. The task was a laborious one, because the tissues of the palm stem are notoriously difficult to deal with. But in the hands of Mr. K. N. Kaul of Lucknow, who has evolved his own technique of preparing the sections by grinding,[47] these difficulties have been largely overcome. And what is much more important to the palæobotanist, he has actually discovered a criterion, or rather a set of criteria, which run without any large degree of variation through entire genera. This, of course, is the essence of a natural classification: constancy through groups of generic rank, with variations marking species within the genus. Mr. Kaul will expound his results before you himself this morning, but I may briefly state the main point he has made. The chief basis of his anatomical classification is the ground tissue.[48] Relying upon this basis he has been able to show [49] that the fossil species which I had named *Palmoxylon coronatum* is anatomically a *Borassus*, that my *Palmoxylon mathuri* is a *Bactris* and that my *Palmoxylon sundaram* is a *Cocos*. The work is not yet complete, but it will be agreed that the back of the problem is broken. We should now be in a position to refer at least the best preserved of our *Palmoxyla* to natural genera of palms.

### *Other Tertiary floras.*

I do not propose to detain you long over the other Tertiary floras, of which the remains we find preserved in numerous places, scattered far and wide in the country.[4, 18, 24, 25, 27, 84, 85, 97, 125, 126] I have elsewhere [75, 89] given an indication of the wealth of this material, and of its great interest in connection with the geographical distribution of modern floras.

Apart from the Deccan Intertrappean series, by far the most important of our Tertiary plant-bearing strata are those of the Siwalik System and its equivalents. These are exposed along the foot of the great mountain belt stretching from Sind in the west to as far as Burma in the east, and they correspond in age to the Miocene and Pliocene of Europe. These extensive formations have yielded a rich flora of modern aspect: leaf impressions of angiosperms; petrified wood both of dicotyledons and palms; fruits and seeds. Several of our *Palmoxyla* come from the Pegu and Irrawady series of Burma, which are believed to cover the period from the Oligocene to the Pliocene; both these sseies contain a great profusion of silicified wood, evidently derived from rich forests not unlike those of modern Burma.

### *The Pliocene upheaval of the Himalayas.*

About half an hour back I was trying to show how the study of fossil plants has helped us to visualize horizontal earth move-

ments of large magnitude. Before closing this address I should like to refer briefly to another aspect of geology on which recent palæobotanical work in India has thrown light. I mean vertical movements of the earth's crust, leading to the formation of mountain ranges. We have already seen that the chain of mountain arcs from Baluchistan to the Malay Archipelago replaced a former line of weakness in the earth's crust; and like the seams of a patched up garment it is a raised line. Let us see how the study of fossil floras helps us to understand this most recent of all seams in the earth's crust.

Its relation with the arrival of conifers in northern India.

From a revision of the Indian fossil conifers,[82, 89] undertaken about ten years ago, the striking fact emerged that in the Tertiary flora of northern India and Burma there was no trace whatever of this group of plants. Conifers, as we all know, cover vast areas in the Himalayas today. But even the younger strata of the Siwalik System, which, the geologists tell us, were deposited during the Pliocene, have yielded no trace of conifers. The first evidence of this group appears in the overlying Pleistocene beds in which the characteristic winged pollen of Abietineæ has been recognized. The advent of the coniferous flora of the Himalayas must therefore be placed at a date towards the end of the Pliocene or even later. Now the great majority of Himalayan conifers, the deodar, the spruce, the silver fir, yew, juniper and others are plants of cold or cold temperate climates. It is therefore a plausible idea that the coniferous invasion of India was postponed till the elevation of the Himalayas had provided a climate suitable for the growth of these alpine and sub-alpine plants. And this idea fits in generally with the findings of geologists: the Pliocene was a period of marked orogenic upheaval in the Himalayas, though the final upheavals did not come till the Pleistocene.

## Pleistocene Floras.

### *The Karewas of Kashmir.*

Let us now follow up the clue a little further and see what the Pleistocene flora has to tell. Perhaps the most fascinating of Pleistocene floras is that of the Karewas of Kashmir,[109] to which Godwin Auston drew attention over 70 years ago. Some of these Karewa beds are richly fossiliferous lake deposits containing a varied assemblage of forest trees and shrubs as well as aquatic plants, frequently associated with fish bones and fresh-water shells. They must have been laid down in a vast body of water, possibly a series of connected lakes, covering an area much greater than the present valley of Kashmir. In the valley the beds lie horizontally, as they were originally laid down. But the same strata have been traced in a continuous series

up the slopes of the mountains on either side and here they lie tilted towards the valley at angles up to 30 or 40 degrees, the dip gradually decreasing as we approach the valley. Isolated Karewa patches have been found on the N.E. slopes of the Pir Panjal range even at altitudes of 13,000 feet or more.

*The Himalayan uplift since the advent of Man.*

Within the thickness of over a thousand feet of these strata there are three or four glacial horizons, corresponding to those in the Pleistocene of Europe. The fossiliferous horizons represent only the mild interglacial periods. What is more, at least in one of these interglacial beds, not far from Srinagar, Dr. de Terra has recently found stone implements, apparently marking the arrival of Palæolithic man,[34] and in a slightly higher layer at the same spot were discovered pieces of charcoal, and the clay figure of an ox. It is evident that we are now rapidly getting down to our own times. And who knows but that our present civilization may after all be only an interglacial episode within the Pleistocene!

But I find I am digressing. I must talk about the plant fossils and their connexion with the Himalayan uplift. In a collection of Karewa fossils from near Baramula my late colleague Dr. S. K. Mukerji (see [109]) recognized the leaves of a large number of modern species, while Dr. Wodehouse [157] and Dr. S. C. Varma have identified the pollen grains of several conifers and dicotyledons. To mention only a few of these plants, we have the pine, deodar, spruce and silver fir; also the oak, willow, poplar, box and rhododendron, as well as aquatic plants such as the water nut (*Trapa*), *Vallisneria* and stoneworts. As for the water plants, the same species still flourish in the lakes and streams of the valley of Kashmir, into which also the leaves of trees from higher altitudes are still being washed down.

The geological interest of these aquatic species lies in the fact that while in the valley, which is only a little over 5,000 feet above sea-level, they live in a mild climate, their fossil remains have been found in the Karewa beds at altitudes where they could not possibly exist today. At Bota Pathri near Gulmarg I have collected fossil fruits of *Trapa* from a height of 9,500 feet, where snow lies for the greater part of the year (figs. 10, 11). The only conclusion is that the Pir Panjal Range has been upheaved through several thousand feet since the time when these plants lived in the great Pleistocene lake of Kashmir.

This conclusion is by no means new. Godwin Austen had already acutely suggested that a great part of the Himalayan uplift had probably taken place since the advent of Man. Indeed the suggestion might even be ventured that Palæolithic Man

may have been able to migrate freely between India and China by the direct route across the region of the Himalayas which at that time may not have been high enough to form an effective barrier.[110]

## The Relation between Palæobotany and Archæology

The fact that some of these recent palæolithic finds in northern India are geologically datable provides a valuable link between the time scales of the palæobotanist on the one side and of the archæologist on the other. And one might perhaps with advantage venture a plea for a closer co-operation between workers in these two fields. For instance, a visit to the prehistoric mounds at Harappa last year brought to light some charcoal of the wood of a conifer, showing that already at that early date (at least 2,500 B.C.) our people were in touch with the forest wealth of the Himalayas, possibly through the medium of the river Ravi. In the Khokrakot mound at Rohtak, in the Jumna valley,[108] which is now being excavated, some terra-cottas, after chemical treatment like fossil incrustations, have revealed the cuticles of paddy husk. In some of these cuticles the form of the cells and the distribution of the stomata can be made out; and the form of the spikelet is also clearly impressed upon the clay, with which the husk was mixed. Some of these impressions bear a remarkable likeness to *Oryza sativa* var. *plena*, which is distinguished by the presence of more than one grain of rice in each spikelet (figs 12, 13). If the date of these terra-cottas can be fixed archæologically, it may show that this interesting variety of rice was already known to the Yaudheya tribes in the rich province of Bahudhāñaka, just about 2,000 years ago.

Investigations on these lines promise much towards an elucidation of the origin of many of our cultivated plants. For, according to the latest researches of Professor Vavilov (whom we are particularly sorry not to find amongst us today) it would seem that it is in this country that this debated problem is most likely to find solution.

## Conclusion.

Ladies and Gentlemen,

In the brief course of this hour we have seen a passing show of our fossil floras, from the earliest down to the most recent. We have seen that the study of these floras is not only interesting in itself, or to the botanist alone; but that through this study the botanist has been able to repay at least a part of the debt that he owed to the geologist. We have seen, too, that a critical study of archæological plant-remains is likely to yield data of value to the historian. With the inevitable speciali-

zation of our age continually threatening to divide us, it is no small gain to Science in India that the brief period of seventeen years that we have just reviewed has brought about an era of understanding and co-operation between us, with still higher promise for the future. For the true aim of all Science is to unite, not to separate.

But if I were to tell you what it is that has impressed me most, amongst the individual results achieved through this concerted work between scientists in different fields, then I would say that it is the realization of the great instability of our earth. Entire continents are drifting. Whole mountains are upheaving: almost before our very eyes. For have we any reason to believe that these movements came to a stop with the arrival of our own species upon the earth? It is true we have at present no means, in India, of measuring the progress either of the horizontal or of the vertical movements that have led to the birth of our unbelievably youthful Himalayas. But with the advent of the wireless the technique of recording the position of points on the earth's surface, particularly of their meridia, has become so perfect, that it should be possible for a man, within the brief span of his active life, to detect any drift movements, well beyond the range of experimental error. We may therefore hope that accurate readings of longitudes will some day yield direct proof that the distance between, say, Western Baluchistan and Eastern Burma is steadily diminishing. For the present, however, the absence of critically placed recording stations is a practical difficulty in the way.

As for the vertical movement of the Himalayas, we have seen that recent work in India in which, I am glad to be able to say, palæobotany has had its share, shows beyond doubt that this uplift is largely a matter of the human epoch.[35–37, 7–10, 145, 109, 110] Indeed all the most recent investigations go to show that these mountains, far from being an inert mass, are more like a living, moving, responding organism.

But, after all, is there anything in this fleeting world of ours that is really at absolute rest?

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## Explanation of Plate.

FIG. 1. *Pityosporites* sp. Lower Gondwana (Talchir stage) of Kathwai, Salt Range, Punjab; horizon 1½ ft. above the Talchir Boulder Bed. × 380.

FIG. 2. *Pityosporites* sp. Locality and horizon as above. × 380.

FIG. 3. *Pityosporites* sp. Newcastle Coal Measures, (Permocarbonif.) Newcastle, N.S.W. From a piece of shale crowded with *Glossopteris browniana* Bgt. × 400.

FIG. 4. *Pityosporites sewardi* Virk. Locality and horizon as above: from the same piece of shale. × 400.

FIG. 5. *Tæniopteris spatulata* McCl. Rajmahal stage (Jurassic); Loc. Nipania, Rajmahal Hills. Transv. sec. of petiole (diagrammatic). *cpx* centripetal xylem, *cfx* centrifugal xylem, *px* protoxylem, *ph* phloem. × *ca.* 35.

FIG. 6. *Amomocarpum affine* sp. nov. Deccan Intertrappean series (Eocene). Loc. unknown. Hunter and Hislop Coll., Brit. Mus. Impressions of two fossil fruits. Nat. size.

FIG. 7. *Amomocarpum affine* sp. nov. A plasticine cast of the same specimen. Nat. size.

FIG. 8. *Elettaria Cardamomum* Mat. & White, a living specimen for comparison. Nat. size.

FIG. 9. *Nipa* (*Nipadites*) *Hindi* (Rode) Sahni, Deccan Intertrappean series (Eocene) of Mohgaon Kalan, Chhindwara Dist., C.P. Transv. sec. of drupe. Nat. size. (Coll. K.P. Rode.)

FIGS. 10, 11. *Trapa* sp. Upper Karewa series (Pleistocene) near Bota Pathri, Pir Panjal Range, Kashmir, alt. *ca.* 9,500 ft. Fruit, nat size. 10a, spine with barbs, × 4½. (Coll. B. Sahni.)

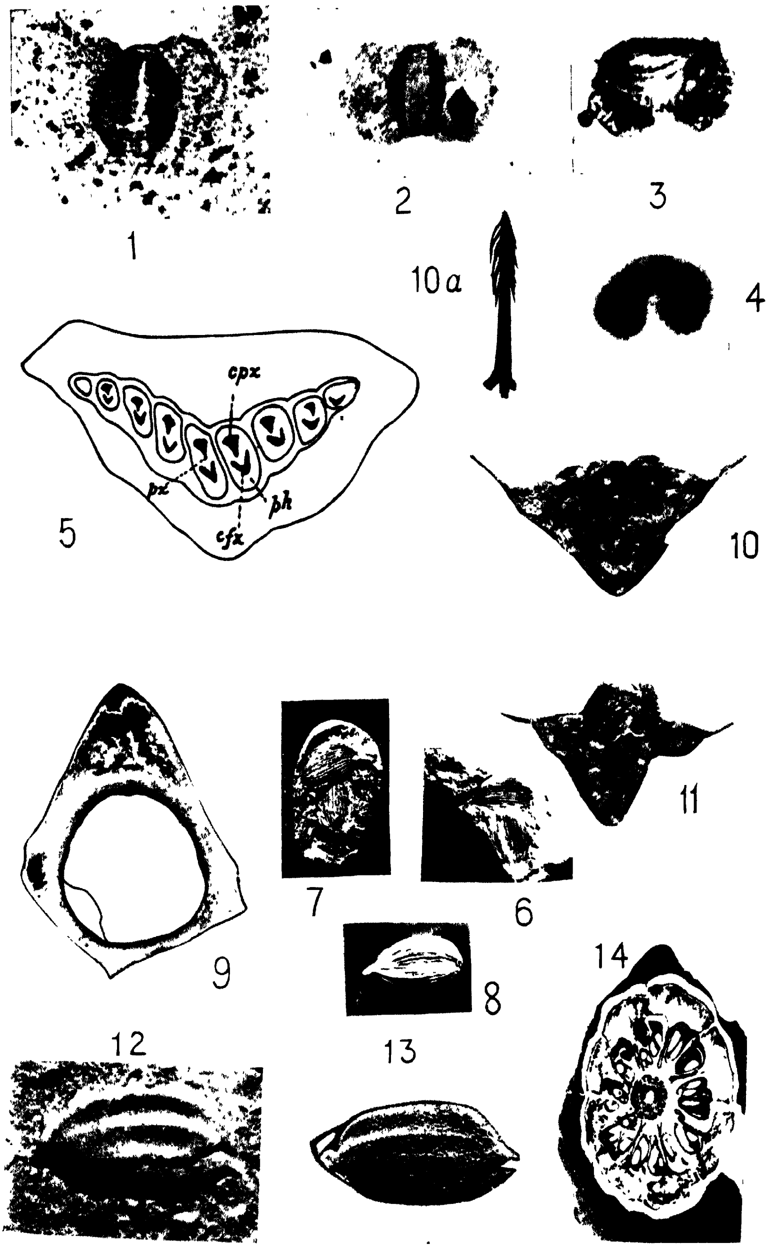
FIG. 12 *Oryza sativa*. Impression of spikelet on baked pottery, showing form of paleæ and epidermal cells. The actual impression is concave, but it appears convex in the photograph. Surface find from the Khokrakot mound, Rohtak, Jumna valley. × 4·3. (Coll. B. Sahni.)

FIG. 13. *Oryza sativa* var. *plena*. Modern, for comparison with the fossil impression in fig. 12. × 4·3.

FIG. 14. *Enigmocarpon Parijai* gen. & sp. n. Deccan Intertrappean series (Eocene) of Mohgaon Kalan, Chhindwara Dist. C.P. Transv. sec. of 8-loc. fruit, with thick spongy wall; dehiscence loculicidal. × 2.

FIGS. 1–4 after Miss Virkki; the rest are original.

SAHNI : Recent advances in Indian Palæobotany.



# SECTION OF ZOOLOGY

*President* :—G. Matthai, M.A., Sc.D., F.L.S., F.R.S.E., F.N.I., I.E.S.

## *Presidential Address* [1]

### ZOOLOGY AND ITS ADVANCEMENT IN INDIA

At the outset I have to express my thanks to the authorities of the Indian Science Congress Association for asking me to preside over the Section of Zoology at its Silver Jubilee Session. This is an honour renewed—since 1920 when I was called upon to act as Chairman of the Section of Zoology and Ethnography in the unavoidable absence of the sectional President of that year and again in 1923 when the tenth Indian Science Congress met at Lucknow—to the School of Zoology in the Panjab University, that has contributed not a little to the progress of zoological knowledge in India, and has sent its sons during the past 25 years to fill eminent places in this country for advancing zoological research and directing the organization necessary for the promotion of that research in all its aspects.

For this reason, and because we are this week celebrating the Silver Jubilee of the Indian Science Congress that has consistently given stimulus and encouragement to zoological research in all parts of this country, I have thought it fit to address you on the subject of Zoology and its Advancement in India.

When the Indian Science Congress was founded in 1914, there seemed to have been only four centres where zoological research was being carried on, namely, Madras, Calcutta, Lahore and Allahabad. To-day there are organized Departments of Zoology in several University centres in India. Considering the financial difficulties in this country the progress that zoological research and organization has made has been most gratifying. While in 1914 there were barely half a dozen Indian zoologists engaged in research work, there is to-day a band of well-trained devoted research-workers in this country, with not a mean record of published contributions towards the advancement of zoological knowledge.

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[1] The information contained in this address has been collected from published papers and from zoological colleagues in India.

Judging from the printed proceedings of the first three sessions of the Indian Science Congress held at Madras, Calcutta and Lucknow, no presidential addresses seemed to have been delivered when the Section of Zoology met in succession under the chairmanship respectively of the late Dr. J. R. Henderson, the late Dr. N. Annandale, F.R.S. and Dr. W. N. F. Woodland. At the fourth session held at Bangalore in 1917 Sir Ramunni Menon, the President of our Section, then designated as the Section of Zoology and Ethnography, in opening the proceedings 'disavowed any intention of giving an introductory address' and the few remarks that he made filled but one paragraph. The printed proceedings of the fifth Indian Science Congress held at Lahore in 1918 contained the record of the first presidential address delivered before the Section of Zoology and Ethnography on a special branch of Zoology, viz., Ichthyology. In the presidential addresses that followed the themes selected were general, historical, ecological or on special groups or special problems. Of the three eminent zoologists who were called to fill the office of General President of the Indian Science Congress, the late Sir A. G. Bourne, F.R.S. at the fourth Session held at Bangalore in 1917 dealt with science in general in his presidential address. The late Dr. N. Annandale, at the eleventh session held at Bangalore in 1924, and Lt.-Col. Seymour Sewell, F.R.S., at the fourteenth session held at Lahore, in 1927, spoke on Evolution, the former from the ecological point of view and the latter from the standpoint of Experimental Zoology.

In his presidential address before the Section of Zoology of the eighth Indian Science Congress held at Calcutta, in 1921, Dr. F. H. Gravely dealt with the history of Zoology in India and Ceylon since 1659. It is not, therefore, necessary to traverse the ground already covered in that address. We shall confine our attention to what has been accomplished since the foundation of the Indian Science Congress in 1914, more particularly since 1921. At the tenth Indian Science Congress held at Lucknow, in 1923, I ventured to address the Section of Zoology on 'Oceanographical Investigation with special reference to the Indian Ocean', summarizing the history of the various methods in oceanographical research and of the attempts at exploration of the Indian seas. This was followed up at the twentieth session held at Patna, in 1933, by Prof. R. Gopala Aiyar in his presidential address before the Section of Zoology on 'Some aspects of Marine Biological Research'.

The investigation of the Indian Ocean with a view to a proper understanding of its Marine Biology was conducted, since the first meeting of the Indian Science Congress, mainly by the R.I.M.S. 'Investigator' (till 1926) and the John Murray Expedition (1933-1934) under the direction of Lt.-Col. Seymour Sewell. Previously the 'Sea-lark' Expedition had surveyed the Western Indian Ocean, south of the Maldives, more particularly

the islands of the Chagos Archipelago and the Mascarene region (during 1905-1906 and 1908-1909). The work of the 'Sea-lark' Expedition was mainly concerned with problems relating to coral reefs and atolls and their Biology, and was a continuation of a previous study of the Maldives and Laccadives. Deep-sea exploration was not part of its programme. The R.I.M.S. 'Investigator' concentrated its work in the Andaman Sea and the Bay of Bengal. The recent work of the John Murray Expedition was in the region of the Arabian Sea, not covered by the 'Sea-lark' Expedition, to the north of the Chagos Archipelago and the Mascarene region, extending to the south and south-east as far as the Seychelles, Maldives and the Chagos Archipelago, and to the west as far as the south-east coast of Arabia and the East African Coast, north to the Gulf of Aden and the entrance to the Red Sea and as far as the Gulf of Oman opening into the Persian Gulf. The study of the Deep-sea Biology of this region was assisted by physical, chemical, hydrographic and topographic investigations. The Survey of India collaborated with the John Murray Expedition in the cruise down the Maldives for making pendulum observations with a view to determining the nature of the foundations on which the Maldives and Laccadives are situated.

[1] The faunistic evidence, particularly Mammalian, appears to be against the probability of a previous land connection of the Andamans and Nicobars with the mainland. It also appears that the Andaman Sea was at one time like a comparatively shallow brackish water lake into which flowed the rivers of Southern Burma, and consists at present of a large basin of sea-water extending down to 2,000 fathoms and two much smaller basins to the north-west with a maximum depth of 1,000 fathoms, and that the Andaman-Nicobar Ridge is connected to the north with the Arakan Range of Upper Burma and to the south with Sumatra and Java, the islands themselves being the highest peaks of a mountain, belonging to the Alpine-Himalayan system, which subsided beneath the surface of the sea, leaving channels connecting the Andaman Sea to the Bay of Bengal. There appears to be also evidence of a comparatively recent upheaval which seems to have been due more to the corresponding fall of sea-level than to actual subsidence of land, a process that appears to have been general in the tropical seas. Around these islands are flourishing coral reefs which extend much more on the west than on the east side, as is generally the case with coral growth in the Pacific and Indian Oceans. The coral banks to the west of the Andamans probably constitute a barrier reef extending from Lat. 13°40′ N. down to Lat. 10°26′N., of a total

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[1] *Vide* 'Geographic and Oceanographic research in Indian Waters', by R. B. Seymour Sewell, C.I.E., Sc.D., F.R.S., Parts I–VIII in Memoirs of the Asiatic Society of Bengal, 1925–1935.

length of about two hundred miles with a channel, 40 fathoms deep, intervening between the reef and the coast, and with seaward steep of 250 to 300 fathoms, there being more regular submarine contours on the north and east of the Andaman Sea than on the west. It appears also that the constitution of the bottom-deposits of the Andaman Sea and the Bay of Bengal is due more to the chemical and physical conditions of the upper layers of the sea-water than to the calcium carbonate dissolving more rapidly from the deposits.

The work of the R.I.M.S. 'Investigator' has extended our knowledge in regard to variation—seasonal as well as daily—in the air temperature over the open waters of the Indian seas, to the east (Andaman Sea and Bay of Bengal) and west (Gulf of Manaar and the Laccadive Sea) of the Indian Peninsula, in the time of occurrence of the diurnal maximum temperature, in the wind force, in the humidity of the atmosphere, and in the amount of rainfall.

A study of the temperature of the coastal water of the Andaman Sea indicated that there was a yearly double-oscillation in the surface temperature of the sea similar to that of the air temperature, that the daily range of temperature and the time of occurrence of the maximum temperature of the surface water was subject respectively to seasonal and monthly variation, that in the case of the air-temperature there was correlation between the mean temperature, average daily range of temperature and the time of occurrence of maximum temperature, that the temperature relationship between the surface water and the air was liable to variation. There was also evidence indicative of a correlation between the rise and fall of the tide and of the salinity and density of the surface water, of seasonal variation and periodic oscillations in salinity and density (the former manifesting itself in a yearly double-oscillation) and finally of the existence of a binodal 'seiche' in each of the two axes of the Bay of Bengal as shown by the salinity of the surface water fluctuating periodically.

Somewhat analogous results were obtained by a study of the surface water of the open Indian seas with regard to variations in temperature, there being a double-oscillation in the seasonal variation and in the mean daily range of temperature comparable to those of the air, and with regard to correlation between the monthly mean and the maximum daily range of temperature, with certain differences in the different regions of the Indian seas. It was also seen that, as in the case of the supernatant air, so in the surface water of the open sea, average temperature variations, daily range of temperature and the onset of maximum temperature were correlated. The relationship between the temperature of the sea-surface and that of the air varied in the course of the year and over the Indian seas, the temperature difference depending mainly on variation in the wind-force in

the Indian seas generally. The salinity of the surface water is subject to daily double-oscillation, which undergoes seasonal alteration as, during monsoon months, dilution takes place by rain-water or by an increased volume of water flowing into the sea from the larger rivers. It was also found that there was a daily, in addition to a yearly, double-oscillation in the wind-force in the open Indian seas, causing the deeper water to rise up and be mixed with the surface water. Such a vertical movement of water would influence the correlation in the temperature of the sea and the air, and would modify the salinity and density of the surface water.

In the Indian Ocean, as in other great oceans, there is always a vertical circulation of the layers of water, caused largely by differences in temperature and salinity. It has been shown that in the Indian Ocean, more particularly in the Laccadive Sea and the Bay of Bengal, there are at least four more or less horizontal layers of water, with different temperatures at different depths, extending from the bottom Antarctic drift to the surface water that is constantly being diluted by the out-flow of river-water : (1) an uppermost surface layer characterized by high temperature and low salinity which flows towards the north-east or towards the south-west according to the monsoons, (2) a layer of water from the polar region, 600–700 fathoms deep, flowing mainly towards the north, (3) a layer of low salinity, between 700–1,100 fathoms flowing towards the south, (4) the lowermost layer, which is the Antarctic bottom drift, with a northerly direction. The iso-thermal lines show a rise from the Maldive archipelago to the Andaman and Nicobar islands. With regard to the iso-halines in the Indian seas, it has been noted that in the Laccadive Sea, north of the equator, water of over 35·0 salinity exists in Long. 74°–79°E. down to a depth varying from 328 fathoms in Long. 74° 45′E. to 1,094 fathoms in Long. 76°47′E. In the Bay of Bengal, water of the same salinity occurs in Long. 88°E. from 109–219 fathoms, in Long. 96°–97° E. at a depth of 820 fathoms, the salinity decreasing to 34·8–34·7 at lower levels.

The average temperature of the sea-water varies slightly from 28°·31C. at the surface to 26°·75C. at a depth of 25 fathoms. Lower down the temperature of the sea-water falls rapidly to over 3°C. in each 25 fathoms, thus at a depth of 125 fathoms the average temperature is about 13°C. A discontinuity zone is thus postulated at depths with a fall of temperature of over 3°C. in an interval of 25 fathoms.

Of the equatorial surface currents in the Indian Ocean the north equatorial current flows from the Andaman Sea towards the Somali coast, whilst the contra-equatorial current to the south between Lat. 2°–5°S. flows in the opposite direction extending down to a great depth. The north equatorial current is, however, neutralized by the south-west monsoon. The

Antarctic Bottom drift divides in the Indian Ocean into three branches, the western-most branch flows up to the east of Madagascar, the eastern-most moves north, north-west towards the east coast of South India, becoming sub-divided by Carpenter's Ridge, one of the subdivisions flowing between Carpenter's Ridge and the Andaman-Nicobar-Ridge up to Lat. 12°N., whilst the other sub-branch divides again to pass respectively into the Laccadive Sea and into the Bay of Bengal up to Lat. 9°N.

A reversal of seasons is noticeable in the Indian seas at a depth of about 100 fathoms, comparable to the phenomenon that takes place in the temperate seas, November to January being the summer months and the seasonal range of temperature about 3°·5C. Temperature records seem to show that in the Bay of Bengal, from 104 to 2,200 fathoms, there is a double-oscillation in the temperature of the deeper waters, which in the Andaman Sea is delayed by about a month. In the Andaman Sea the temperature below 800 fathoms is influenced by the presence of the volcanic range that runs through it.

The Laccadive and Maldive Archipelagoes which are situated on two plateaux whose depth vary from 1,000 to 1,200 fathoms from north to south, merges at the 1,300 fathom line into a common base connected with Peninsular India to the north, and has a depth of water of over 2,000 fathoms on each side of its southern end. The continental shelf off the west coast of India has a depth of about 100 fathoms, and at one time perhaps formed part of the Indian Peninsula, subsequently sinking beneath the sea by actual subsidence or by rise in the sea level, as evidenced by the faulting along the coast : or may be the result of the deposition of eroded material from the land surface as indicated by certain differences in the different regions. Coral growth occurs off the coast of Ceylon on the comparatively narrow continental shelf. The floor of the Laccadive Sea is said to have considerably subsided in tertiary times. According to Sewell, 'All the evidence that we have been considering seems to indicate that originally between India and Africa lay a connecting mass or series of masses of land forming either a portion of a large continent, namely Gondwanaland, or at a possibly later stage a narrow connecting isthmus, part of the supposed continent of Lemuria, that finally underwent subsidence and was drowned beneath the Indian Ocean, leaving only the topmost peaks as islands. One cannot, however, ignore the suggestion put forward by Wegener in his work on the origin of Continents and Oceans that India and Africa were at one time part of the same land mass and that they have gradually drifted apart' (pp. 436-37). According to the same author, 'A study of the contours of the Laccadive and Maldive regions and of the soundings that have been taken on the two sides, shows clearly that the basis on which these coral reefs and atolls are perched

is a magnificent mountain range that at the present day rises at its southern end from a depth of over 2,000 fathoms and that, if we include the Chagos region, extends through a distance from north to south of nearly 1,500 miles. This great mountain chain runs in a nearly north and south direction and as one would expect in a range of this magnitude, exhibits at certain points along its length breaks in its continuity, some of greater extent than others, that are quite comparable to the various passes that one finds in mountain ranges on land. As a result of these breaks, the islands now marking the topmost peaks are divided into geographical groups, each of which is still further subdivided into a series of banks and plateaux' (p. 437). This mountain system is said to have been continuous at one time with the oldest mountain range in India, namely the Aravalli Mountains. The Laccadive-Maldive Ridge was subject to sub-aerial erosion owing to exposure to the south-west monsoon. As the ridge sank beneath the sea level, marine erosion would transform the ridge into a number of plateaux. These changes apparently took place at the close of the tertiary epoch, and corals began to grow on the eroded plateaux when the glacial epoch terminated. Analogous changes took place in the Bay of Bengal, resulting in the formation of the Andaman Sea bounded to the east by a mountain range which, unlike the Maldive-Laccadive Ridge, was not entirely sunk beneath the sea surface. According to Sewell, the available evidence is 'in favour of the view that the general conformation of the basis on which the present-day atolls and reefs of these Archipelagoes are situated is the result of sub-aerial and marine erosion on a gradually but continually sinking mountain range' (p. 444), whilst Stanley Gardiner had previously accounted for the present condition of the Maldives to submarine erosion extending to a depth of about 200 fathoms brought about by the action of currents, and not due to recent subsidence of land. According to the latter author it was hardly likely that the islands on atolls were formed by the action of wind and waves in piling up sand and coral detritus, but resulted from a slight fall in the sea-level that occurred comparatively recently (about 4,000 years ago). Along the coast and islands of the Indian seas, evidence is forthcoming of a comparatively recent fall in sea-level (15–20 feet), such as exposed masses of dead coral (as in the Mergui Archipelago), elevated sea beach (east coast of India), raised coral beaches, (Andaman and Nicobar Islands), broad flats (Ceylon), raised coral reefs (South India, near Pamban), raised beaches (south-west coast of India). Similar changes in sea-level have also been taking place in the Chagos Archipelago and the Mascarene region.

In areas of coral growth the building up of the reefs and atolls is assisted by the corals themselves and by Nullipores, as well as by coral débris subsequently consolidated into 'conglo-

merate rocks ' and various kinds of limestone. The deterioration of the reefs is caused by the erosive action of currents and waves and boring organisms such as sipunculids, holothurians, algæ and sponges, by changes in the normal temperature and salinity of the sea-water. Studies on coral reefs have shown that conditions vary in different regions, necessitating the investigation of atolls and reefs with special reference to local conditions. Reef-forming corals cannot grow at a depth greater than 25 to 30 fathoms owing to insufficiency of sunlight in the deeper layers of the sea. In the estuarine region of the Indian seas such as the mouth of the Ganges (Bay of Bengal), and of the Indus (Arabian Sea) reef-forming corals do not occur owing to adverse conditions resulting from the deposition of mud and silt and perhaps also to dilution of the sea-water. In studying coral-reef formations in the Indian seas it is necessary to bear in mind the temperature factor in the deposition of calcium carbonate by the rapid evaporation of sea-water, which assists in consolidating coral débris into coral conglomerate, the importance of encrusting Nullipores such as *Lithophyllum*, *Lithothamnion* in reef-formation, particularly of the outer part of the reef, the value of surface currents in the open seas bringing food material, and of waves in assisting the formation of Nullipores. In the Maldives and Laccadives both sides of the atolls get the benefit of surface currents and waves owing to the north-east and south-west monsoons occurring at different times of the year. Hence coral growth on both sides of these atolls does not present much difference. In the case of any gradual subsidence of land or rise of the sea-level reef corals, by their continuous growth, will be able to keep the reef surface at the level of the sea. If the change should take place suddenly the reefs will become submerged coral banks. Such submerged coral banks are found in the western region of the Indian seas, particularly in the Chagos Archipelago, the Great Chagos Bank being a well-known instance of a submerged atoll with raised margin 5–10 fathoms deep, the central lagoon being 45-46 fathoms deep. One of the reasons (Stanley Gardiner 1930, p. 8), why the submerged coral banks at a depth of more than 10 fathoms are unable to raise themselves up to the sea-level, is because the corals and calcareous algæ are killed by the deposition of amorphous carbonate of lime precipitated from the supersaturated sea-water by chemical action of their chlorophyll on carbon dioxide, neither the movement of waves and currents nor the ciliary action of the coral polyps being sufficiently effective at such depths to remove the calcareous deposit. When the seaward edge of the outer reef of atolls is fully exposed to the action of waves, particularly during the monsoon seasons, there is rich growth of *Lithophyllum* protecting the exposed seaward edge against the continuous action of waves that prevent the growth of reef corals as seems to be the case in the Maldive atolls. The islands

on the reef flat of some of the atolls of the Laccadives and Maldives may have been formed by the action of waves in piling up coral débris on the reef-flat, or by elevation of the coral-reefs consequent on a fall of the sea-level, the raised reefs subsequently becoming divided by erosion and by the formation of deep channels as in certain parts of Minikoi atoll, the Laccadive Archipelago and in the North Malos Bank in the Maldives (Stanley Gardiner 1903, pp. 34–36, 149 and 171).

Precipitation of calcium carbonate may take place in various ways, when fresh water from the land supersaturated with lime meets the salt water of the sea, such action taking place between tide levels (Stanley Gardiner 1930, p. 16 and 1931, p. 43), by the action of denitrifying bacteria (Drew 1914), by the action of decomposing organic matter, by the photosynthetic action of algæ and by evaporation consequent on rising temperature.

The seaward side of the islands in the Laccadives and Maldives is being continually eroded by the action (solvent and mechanical) of waves, particularly in the case of those atolls that lie in the direction of the south-west monsoon. In Diego Garcia situated to the south of the equator, erosion has taken place only where the entrance channels pass into the lagoon, since this island is not affected by the south-west monsoon. Comparative absence of erosion on the east and south-east sides of the Laccadive and Maldive atolls probably account for the presence of numerous atolls on those sides. The eroded débris and sand from the seaward face of the atolls is driven over into the lagoon and is deposited on the lagoon floor. This material as it accumulates on the lagoon side begins at a certain stage to undergo erosion. Erosion taking place on both sides would ultimately wipe out the island. It seems to be a common occurrence that coral reefs on the lagoon or seaward sides have a vertical steep. There is abundant coral growth on the inner side of lagoon reefs in the Indian seas, the reef itself sloping to a depth of 1-2 fathoms, then dropping down to a steep which may get undercut by various agencies such as solution, erosion, destruction by boring organisms. The undercutting is perhaps due to certain factors, in the deeper parts of the reefs, that inhibit or retard coral growth, such as lack of sunlight, higher temperature of the sea-water that in high tide flows over the reef-flat down to the lagoon bottom, this water, while deficient in oxygen and food contents, carries products of erosion to the bottom of the lagoon. In the case of atolls lying north to south the upper part of the steep will overshadow the lower region for part of the day, thus adversely affecting coral-growth in the deeper parts. Since the deposition of sand and mud on the upper part of an atoll will be adverse to coral-growth the reef-flat may become discontinuous. In the coral reefs and atolls in the Indian seas where erosion is taking place there are indications of coral destruction on the reef-surface, ultimately resulting in the breaking up of the reefs, a

good example of which is the Horsburg Atoll of the Laccadives in which Stanley Gardiner noticed in 1903 (pp. 307–380) disappearance of land on the south and west sides whilst on the north and east sides erosion was actively taking place. Large quantities of débris resulting from the destruction of land has settled on the upper part of the lagoon reef. With the complete disappearance of land on the south and west sides, deposition of silt will no longer take place, and reef building corals could grow on the north and east sides, thus assisting in the formation of a steep. In the larger lagoons the greater part of the bottom is hard, sediment (consisting of reef detritus, skeletal remains of pelagic organisms, and calcium carbonate precipitated from the sea-water) occurring on the floor of the smaller lagoons. In the lagoons both destructive and constructive processes are at work, if the former is more active the lagoon will widen, if the latter process is more rapid the reef will extend into the lagoon and may ultimately displace it. In the Indian Ocean there are several instances of lagoons tending to become shallow towards the windward side (the prevailing winds being mainly the south-west and north-east monsoons). The detritus from the windward reefs tends to get evenly deposited on the lagoon floor by the action of waves and currents, but occasionally may get aggregated on the lee-ward side of the reefs.

With regard to the channels that connect lagoons with the open sea, the deeper ones were probably present from the commencement of the formation of the coral bank, as coral-growth from such depths was impossible, whilst the shallow channels perhaps had a secondary origin by the deposition of detritus killing coral-growth.

[1] Our knowledge of the topography of the western region of the Indian seas has been extended by the recent John Murray Expedition. The Gulf of Aden is 900 to 1,400 fathoms deep, the depth changing abruptly and the central region being characterized by the presence of ridges alternating with troughs. The contours at the western end run from east to west, whilst at the eastern end and in the middle they are from north-east to south-west. The south-westward ridge from Ras Fartak, about 120 miles long, has on it a depth of 700 to 800 fathoms, its eastern side suddenly dropping to over 2,000 fathoms; depth of over 2,700 fathoms (12,000 ft.) has been determined by two soundings towards its north end, the greatest depth so far recorded for the Gulf and the Arabian Sea. A gully runs by the side of this ridge. There is no evidence of the ridge in the centre of the Gulf having any connection with the mainland. In the Arabian Sea and the entrance to the Persian Gulf, between

[1] *Vide* 'Scientific Reports of the John Murray Expedition', Vol. I, Nos. 2–5, 1935 and 1936, and 'Nature', 1933 (Vol. 131, pp. 640 and 641), 1934 (Vol. 133, pp. 86–89, 669–672; Vol. 134, pp. 685–688).

Khorya Morya Islands and Ras al Hadd, the decrease in depth is rapid between the 1,000 fathom and 500 fathom lines. The decrease to the 250 fathom line is more gradual, then steep to 60 fathoms. There was no evidence of corals in a bottom sample taken from the San Carlos Banks. The Murray Ridge discovered by the expedition 'appears to be the continuation of one of a series of banks that run in a south-westerly direction from Karachi, possibly a submerged connection of the Pab Mountains. It differs, however, in one respect, in that while it appears to be steep to, and uneven on its summit, the others appear to be more in the nature of shelving banks. In longitude 64°E. three separate banks appear. The northern one rises from 1,730 to 964 fathoms and falls to 2,000 fathoms on its southern side, from which the second ridge rises to 790 fathoms. The third bank rises to 413 fathoms, and is probably separated from the second by a depth of about 1,200 fathoms ....... The gully of 2,000 fathoms that separates the two northern banks is similar to the one that lies on the eastern side of Murray Ridge. It is the existence of these gullies that make it probable that they are connected, and that the Murray Ridge is a continuation of the northern bank' (Farquharson, p. 50). The Ridge appears to be continued to the south in Lat. 16°N. and Long. 60°E. and ultimately connected with the Carlsberg Ridge in the Indian Ocean. The Makran Basin has a depth of 1,750 to 1,830 fathoms to the north of the line from Ras al Had to the Murray Ridge, has a smooth bottom and bounded on the north (60 miles from the mainland) 'by a barrier that usually rises between 400 and 500 fathoms from the general depth' (Farquharson, p. 51). Between the barrier and the Makran coast there are ridges and valleys more or less parallel to the coast, the depth of the valleys exceeding that of the barrier by 200 or 300 fathoms. The south-eastern boundary of the Makran Basin is formed by banks that extend from Karachi.

The Carlsberg Ridge divides the western region of the Indian Ocean into north-eastern and south-western halves, and was so named by Dr. Johannes Schmidt who crossed it on the 'Dana'. The direction of the Ridge is to the south-east from Socotra continued south from the Equator and then south towards the Chagos Archipelago as far perhaps as the island of Rodriguez. The Ridge itself appears to be double. The north-eastern basin of the Indian Ocean lying between the Maldives and Laccadives on the east, the bank extending south-west from Karachi on the north, and the Chagos Archipelago on the south is about 2,400 fathoms deep, being continuous through the channel between the Chagos Archipelago and Addu Atoll, with the deep waters to the south-east. The south-western basin is about 2,700 fathoms deep to the north, and appears to be divided towards the south by a plateau less than 1,000 fathoms deep, connecting Mauritius with the Seychelles through Cargados

Carajos, Nazareth Bank and Saya de Maha Bank, and having a possible extension to the north. There appears to be a common ridge above the 1,300 fathom line on which the Maldives, Minikoi and the Laccadives are situated, Minikoi itself being part of the Laccadives, as suggested by irregularities in slope and contour, rather than of the Maldives. King Fuad Bank is probably a submerged atoll with a distinct rim about 40 feet high and a level floor 130 fathoms deep. There is a basin of water with a depth of 1,500–1,640 fathoms between the 1,000 fathom line off the mainland and the upper part of the Maldives, which does not appear to be connected with the deep waters to the south-east.

As a result of the work of No. 14 Party, Survey of India, in collaboration with the John Murray Expedition, for four weeks in March and April, 1934, Lt.-Col. E. A. Glennie reported as follows :—

'The large negative anomalies in the Maldives are remarkable; these increase towards the central meridian of the Archipelago. Precisely the opposite is the case at Minikoi, for the crustal warp anomaly is positive on land and reduces to zero at the sea station to the west, thus indicating a tectonic condition under the Laccadives apparently opposite to that under the Maldives.

From the gravity and deflection observations on the west coast of India it is known that a positive area flanks the coast as far south as Mangalore; if this is extended to Minikoi it is significant that a line drawn from Minikoi to Mangalore will skirt the southern margin of Kalpeni and Androth Islands, Ellicalpeni Bank and other shallow soundings. It seems therefore a plausible deduction that the great positive upwarp off the Bombay coast runs south under the Laccadives to Minikoi, while the flanking depression of the crust on its east side continues out to sea south of Mangalore to the line of the Maldives, where a continental fragment of the crust has been crushed in the downwarp or submerged' (p. 96).

In his account of Addu Atoll, Sewell noted the changes that have taken place after the visits by Stanley Gardiner and Forster Cooper in 1900 and of Agassiz in 1902 with reference to the reef-platform, the outer reef, the islands of the reef-platform, the lagoon reef and the lagoon. It was not possible to ascertain definitely the relative part played by the two factors viz., the summit of the mountain on which the atoll has been formed and the varying growth rate of the reef, in determining the shape of the atoll. The north-eastern horn of the atoll is probably due to the submarine contours tending to extend to the east and north-east. There are coral heads on the south-west side of the atoll brought up by heavy waves during the south-west monsoon which has greater effect on the atoll in spite of its situation below

the Equator than the north-east monsoon, which also probably accounts for the absence of coral blocks on the east side of the atoll. The islands on the west side of the reef-platform occur near its inner margin and are greater in size than the islands on its eastern side. There is also considerable difference between the east and west sides of the lagoon reef. The lagoon floor is poor in regard to coral-growth, due perhaps to the adverse effect of sulphuretted hydrogen which is comparatively abundant on the lagoon floor.

Horsburgh or Goifureehendu Atoll is markedly different from Addu Atoll, as the former is affected by both the south-west and north-east monsoons, being situated in about Lat. 4° 51′ N., Long. 72° 55′ E. On the north and north-east sides of this atoll occurs a row of islands, external to which is the outer reef-flat or boat-channel and to the inside is the lagoon reef-flat. A similar distinction into three concentric zones cannot be made out elsewhere in the atoll as the land has completely disappeared from that part of the reef owing perhaps to the action of the south-west monsoon, that blows heavily on the south and west sides of the atoll. The lagoon floor appears to be basin-shaped, not flat, being deeper in the centre (23 fathoms) than at the circumference, the floor thus sloping upwards from the lagoon centre.

[1] Regarding the reefs of the Western Indian Ocean, it has been recently pointed out that the Mascarene Region, situated farther from the Equator, differs from the Chagos Archipelago in regard to conditions of reef-growth, changes adverse to reef-growth taking place at a much faster rate than in the latter. The Chagos Archipelago seems to have remained unchanged for a comparatively long period of time after the change of sea-level resulted in the appearance of land as in coral reefs generally. With the subsequent seaward growth of the reefs on a 'talus slope' a corresponding extension of land also took place. No land is seen on the 'lagoon shoals' owing to submergence, except when Lithothamnioneæ are present on the bank assisting in the formation of a reef. Reef-forming organisms have not brought about any change in the depth or extent of the lagoon, as their growth is restricted. The banks are to be regarded as having been formed by submergence of land and not as reefs actually growing up. The Chagos Archipelago is separated from the Maldives by a depth of over 2,000 fathoms, the Archipelago itself being situated on a southward extension of the Maldive-Laccadive Ridge to 4° S., with a narrow trough probably inter-

[1] *Vide* 'The Reefs of the Western Indian Ocean—I Chagos Archipelago; II The Mascarene Region', and 'Concluding Remarks on the distribution of the land and marine fauna, with a list of the water temperature observations', by J. Stanley Gardiner, F.R.S., in Transactions of the Linnean Society of London, Vol. XIX, Part 4, 1936.

vening between the Carlsberg Ridge and the Chagos Archipelago. Within the 1,000 fathom line the Archipelago extends from about 4° 40′ S. to 7° 45′ S., the ridge on which it is situated probably extending to farther south at a lower depth. Stanley Gardiner remarks: 'The Great Chagos Bank is the dominant feature of the group, for it is 92 miles across and 63 miles north and south within the 20-fathom line. This gives it a circumference of about 240 miles, on which there are 9 miles of surface reef, 200 miles of shoal water, 5–12 fathoms, and 32 miles in eighteen passages with over 20 fathoms, leading to a great central plateau of 38–48 fathoms with relatively few shoal banks arising upon it. The weather during our visit prevented any investigation of this bank, but the records of Great Chagos, together with the considerable information we collected verbally, do not support the idea that it is an atoll in course of formation, for much of the circumference is said to be bare of Lithothamnioneæ and large coral' (p. 396). In the Chagos Archipelago there appears to be a gradual slope down to about 50 fathoms (the depth limit for the growth of calcareous algæ and reef corals at which the water temperature suddenly drops) before the commencement of the steep, seen in most coral reefs, which is said to be of the nature of a 'talus slope' composed of detritus washed down by currents. The Chagos are situated between the counter equatorial and equatorial currents flowing east and west respectively, and their submarine topography seems to be determined by the currents set up by the tides. It appears that the 'basal platform' of the reefs and banks of the Chagos is within the 850-fathom line, the floor being comparatively smooth and clean. 'This cleanness of the floor at 500 to 800 fathoms, the nature of the "deposit" obtained from it, the absence of any thickness of deposit and the dredgings, irresistibly suggested a current-swept floor between the atolls and banks. A thin coating of "manganese" on some shells and on two pieces of rock torn off the bottom supported this idea' (p. 397). Regarding the formation of the Chagos Archipelago Stanley Gardiner suggests: 'In the Chagos we have to think either of a subsided or of a peneplaned land. The reef-building society evolved in the Cretaceous, producing its wave-resisting structures which are known as coral reefs. This gives the earliest date for the possible commencement of the Chagos coral reefs. It allows a period, perhaps of 10 million years, for a levelling-down of foundations suitable for its atolls and for a possible subsequent increased depth between them, so as to produce the present topography of the Archipelago. Such a recent planing-down may have operated upon a land that was subjected to a similar process even from Archean times.

I do not doubt the former existence of a high land beneath the Chagos Archipelago, this perhaps with mountain peaks. But I see no need to call in the help of any agencies to produce

its present structure beyond the physical and chemical actions of air and water, the effects of these subsequently controlled by the bodies of living organisms ' (pp. 397-398).

Salomon Atoll seems to have been formed by a change in the sea-level, the reef growing on the seaward side. Over the greater part of the lagoon reef-forming organisms seem to have perished, partly by the deposition of mud but chiefly due to the precipitation of lime by the organisms themselves.

In his detailed account of Salomon Atoll, Stanley Gardiner says: 'The intention, when the Percy Sladen Expedition left England, was to chart an atoll in the Indian Ocean in a manner analogous to the chart of Funafuti, so that comparisons of the constructive and destructive forces at work in shaping atolls might be determined after the lapse of a period of time. Salomon Atoll was chosen for this purpose ' (p. 398). Dredging by the Percy Sladen Expedition ' proved unquestionably that the steep is the angle of accumulation of reef material formed in shallow water, the talus slope, all sedentary life upon it unimportant as building material ' (p. 412). In Egmont Atoll also there is evidence of the reefs extending on the seaward side as in the case of Salomon Atoll, with clearer indication of a lowering of the sea-level resulting in the appearance of land. Diego Garcia with more extensive land area than in any other atoll of the Chagos Archipelago is said to be formed by ' recession of the sea ' with seaward growth of reefs all round but loss of land on the lagoon side resulting in extension of the lagoon itself. Peros Banhos, which is an abnormal atoll in several respects, is ' deemed to be in a decaying condition, perhaps in an earlier stage to that found in Great Chagos Atoll ' (p. 420) owing to loss of land being greater than the gain. The lagoon is up to 41 fathoms deep, whilst the passages, of which there are twelve, are much shallower, the maximum depth being only 15 fathoms ; this contrast in the relative depth of the lagoon and the passages connecting the lagoon with the outer sea is a unique feature. Whilst in the Southern Maldives the greater part of the lagoon floor within 10 fathoms of the greatest depth is flat, in Peros Banhos the central part of the lagoon floor is much deeper. Another unique feature is the presence of water (2–4 fathoms) over most of the lagoon shoals. Summarising his impressions, Stanley Gardiner suggests, ' that Peros Banhos is an atoll breaking up rather than in process of formation, its land, originally formed by a small recession of sea-level, gradually washing away though growing out locally, its lagoon not filling-up though its open conditions seemed highly favourable to coral growth. Can Peros represent a stage analogous to one in the history of Great Chagos Bank, still later developed in Speaker's and Pitt Banks ? ' (p. 425).

The Mascarene Region, unlike the Chagos and the Maldive Archipelago, does not possess clearly marked ' zonal structure '. In this region cementing *Lithophyllum* is comparatively absent

from the seaward edge of the reefs (hence without seaward growth), coral growth less abundant, coral colonies smaller but with larger quantity of dead corals on the reefs than in the Chagos Archipelago. Stanley Gardiner held 'that the facts can only be explained on the view that the general action in progress throughout the south-west quadrant of the Indian Ocean is an erosion of all reefs on their seaward faces. This action if long continued would account for the existence of submerged banks, either by the direct truncation of former granitic, volcanic or organically formed lands' (p. 426). According to the same author, 'the chief feature of the south-west quarter of the Indian Ocean is a broad ridge included within the 1,000-fathom line that extends northwards from Mauritius to the Seychelles and probably continues south to the Amirante Bank. It does not join Madagascar, for there would seem to be three breaks of over 2,000 fathoms, viz., south of Amirante, south of Alphonse-Francois and south of Farquhar, all the islands in this region apparently rising from about this depth as isolated plateaux. Of these Providence is known to be connected with volcanic foundations. Except Seychelles (granite) and Mauritius and Réunion (volcanic) all the island rock is limestone of some coral reef facies and most of it would seem to have reached its island position by a lowering of the sea surface that was perhaps of universal occurrence.

The most peculiar structure of the region is the series of submerged banks on the Mauritius-Seychelles ridge. They are all plateaux lying within the depth zone of photo-tropic organisms, which for plants terminates at 60 fathoms or thereabouts and for animal builders, all of prime importance being dependent on symbiotic algæ, at 40 fathoms' (p. 426).

According to Stanley Gardiner the regression of coral reefs in this region cannot be accounted for by any biological reason such as sedentary organisms that cause destruction by boring into the reefs, since the activity of such organisms is decreased at the depths at which reefs of this region are situated, nor by sediment which cannot settle on the seaward sides of reefs and banks nor by precipitation of calcium carbonate for such precipitation is not visible on coral polyps on the seaward sides, nor by currents whose action is less on the sides facing the sea, nor by temperature which at 50 fathoms is not lower than 61°·9 F., nor by any decrease in the amount of plankton that serve as food material to coral polyps, for it is not liable to much quantitative variation in the Indian Ocean, nor does the chemical composition of the surface water in the Indian seas show any appreciable difference. Stanley Gardiner says, 'the only theory that fits our region is that its present coral islands, its encircling ridges and shoals, are the remains of still broader coral structures, perhaps surface structures, that were built up subsequent to the cutting down to a base level of great

lands—and that the processes which produced these effects still continue in action to the present day. Such a theory fits best our phenomena, but we have no valid suggestion of any kind as to why there should be such a regression of the reefs. Topographical reasons and abundant sedimentation may help to explain the absence of reefs round Madagascar and their comparative absence off East Africa, but such an effect off the reefless Arabian coast is less clear—and the question does not arise in the Red Sea, where there are vigorous reefs along more than 1,000 miles of coasts. Ceylon on its south coast has the one slope in our ocean where the topography suggests the former existence of a barrier enclosing a lagoon, but here we have to the south the great Maldive and Chagos Archipelagoes, the reefs of which are as vigorous as those of the more equatorial waters of the Pacific ' (p. 428). In short, ' the formation decay and regression of our Mascarene reefs may have been governed by world changes which may slow down and change but which never cease ' (p. 429).

From his study of the insect fauna of the Seychelles, Scott was inclined to the view (with which Stanley Gardiner agreed) that the Seychelles belong more to the Oriental than to any of the other great Regions. In this connection Stanley Gardiner makes an interesting suggestion that for a further elucidation of the geographical relations of island fauna it would be advantageous to make an intensive study of the fauna (particularly insects) of the Nicobar Archipelago. The fauna of the Seychelles seems to be related more to those of Ceylon and Malaya, although several genera of primitive facies occur in the Seychelles. Stanley Gardiner says, ' a continent between India and Madagascar appeals to us much in the same way as the lost Atlantis to the newspaper public, this continent is no longer a necessity for the distributionalist ' (p. 455). The island history of the Seychelles seems to have continued from early tertiary times. The fauna of the Seychelles appears to be also related to that of Mauritius and Madagascar, suggesting a former land connection between the Amirante and Mauritius. ' The topography of the submerged banks so remarkably resembles that of the Seychelles bank that our deduction that it represents former land may reasonably be applied to them, since they scarcely can be supposed to have been plateaux arising from 2,000 fms. to 50 fms. below the surface ' (p. 455). In order to explain the conspicuous affinities of the Seychelles fauna and flora with those of the Oriental region Stanley Gardiner does not think it necessary to assume any former land connection. ' The time factor is large, the island was a large one and there are numerous banks which may well have been covered with land, and there may too have been a continuation southward of India where the Laccadives and Maldives now stand. The regular wind and wave currents in the region are eminently suitable to bring the plants and beasts

from the Oriental region. Chagos too might have been a station on the way, but always an isolated station, because the poverty of the animals on its banks is not consistent with a former connection to the Maldives. The sea-borne organisms, finding in Seychelles a large and varied land with a multitude of new environments, would naturally react in the same way as all nature has reacted to produce evolution. Thus has been formed that fauna and flora so varied and highly specialized which is characteristic of the present Seychelles Islands. Gondwanaland, universally accepted 30 or 40 years ago, is in my opinion a doubtful proposition ; its existence depends on biological evidence and this assuredly requires no such land of tertiary date across the Indian Ocean ' (pp. 455-456).

Attention is drawn to the comparative poverty of the land fauna of the Chagos Archipelago. The results of the two Percy Sladen Trust Expeditions seem to indicate that the Chagos and the Maldives are of recent origin. The fauna of the Maldives and Laccadives is related to that of the Oriental region, and the Chagos might have derived their fauna partly from the Maldives, but mostly from the East Indies as seems probable from the systematic study of the collections made by the Percy Sladen Trust Expeditions. The latter faunistic relationship is perhaps due to larvæ from the East Indies being carried to the Indian Ocean by currents whose direction is mainly from east to west.

Stanley Gardiner regards the shallow water fauna of the Indian Ocean as having evolved from the north-west and north-east regions of that ocean, subsequently spreading towards the Pacific Ocean. In the collections made by the Percy Sladen Trust Expedition only 254 species were common to the reefs of the Chagos Archipelago and the Mascarene Region, although the total number of species recorded from the two regions was respectively 573 and 557. In these two regions as much as 55 per cent. of the organisms differed from each other, this considerable difference could be accounted for by the fact that in the Mascarene region the reefs are not clean as in the Chagos Archipelago. The former are also less protected against the action of currents. Owing to the rapid decay of the reefs in the Mascarene region the seawater contains much mud and silt which tends to become deposited on the reefs to the detriment of the fauna. On the other hand the reefs of the Chagos Archipelago are in a comparatively stable condition. The fauna of the Mascarene region might have partly migrated from the Chagos Archipelago ; part of the fauna of the Mascarenes might also have been derived from Africa. Thus according to Stanley Gardiner, the Mascarene fauna is ' made up of a combination of organisms belonging to the whole of the Indian Ocean to which is added a limited number which had made their way thus far west from the Malay region together with a larger number that have somehow spread down from the west and north. This conclusion, applied to the two

sets of reef organisms, is perhaps not certain, even a little doubtful, but, if the whole Mascarene fauna to 100 fms. is considered, it becomes at once more probable, in some groups appearing almost convincing' (p. 460). The deep-sea fauna in the Chagos and Mascarene regions seems to have been derived from shallow water forms. It appears to be cosmopolitan in distribution, owing to the prevalence of more or less uniform conditions such as lack of light and currents, composition of the sea floor (largely of ooze or mud), sea-water being uniformly low in temperature but rich in oxygen, nitrates and phosphates, the food material consisting largely of organisms that sink to the bottom as they die. The comparative poverty of the deep-sea fauna in these regions is perhaps due to the hardness of the sea-floor and perhaps also to the fact that the quantity of plankton which serve as food material to the larger organisms is less in the Indian seas than in the temperate regions. In spite of the 'shallow and fierce conditions' of life on the reefs of the Chagos and the Mascarenes it is interesting to observe that the animals do not exhibit any special structural features that may be regarded as adaptations to the peculiar environmental conditions. Stanley Gardiner sums up his observations as follows :—'The conclusion I reach is that there is the deep-sea zone, little varied in the essential features of its environments, and shallower to it a distinct phototropic zone. Between the two is a special region of loose rock masses, which are loved and sought by certain animals from above and below because of their relative freedom from mud. The phototropic area I regard as one zone in a scientific sense, viz., as inhabited throughout by the same flora and fauna, always excepting some few plants and symbiotic animals that may be affected by the strength of the illumination that penetrates to them. Practically considered, however, the phototropic zone is divisible into two parts, which have their centres at perhaps 5 to 30 fms., each with its dominant plants and animals. The differences between the species of these two centres is to be regarded as due to the variations in the environments of the two depths rather than to any definite depth zonation . . . . .' (p. 463).

[1] The Madreporarian corals collected by Prof. J. Stanley Gardiner, F.R.S., in his several expeditions to the Indian Ocean, particularly of the Astræid corals, provided material, augmented by further collections from the Pacific and Atlantic Oceans and the Red Sea, for a comparative study, for the first time, of the morphological organization of their hard and soft parts, with a view to determining, if possible, the limits of species and genera, most previous taxonomic studies on corals having been based on

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[1] *Vide* 'A revision of the Recent Colonial Astræidæ possessing distinct corallites', 'Histology of the soft parts of Astræid Corals', 'Colony-formation in Astræid Corals', 'A monograph of the recent meandroid Astræidæ', by G. Matthai, 1914, 1923, 1926 and 1928.

characters taken solely from the hard parts that are liable to considerable variation. The same material, along with others, formed the basis for an exhaustive study of colony-formation in Astræid corals which was found to be by two main types of budding, intra-tentacular and extra-tentacular. In the former, different conditions were studied—distomodæal, tristomodæal, triple stomodæal, intra-mural (linear) polystomodæal, circum-mural polystomodæal and circum-oral. It was also found that directive couples of mesenteries were either present or absent in Astræid genera, irrespective of the type of budding, whether extra-tentacular or intra-tentacular. Hence the presence or absence of two directive couples of mesenteries, and therefore of biradial symmetry, assumed primary importance in classification. The presence of inter-stomodæal couples of mesenteries between neighbouring stomodæa of di-, tri-, triple, and polystomodæal conditions was a morphological feature no less significant than the presence or absence of two directive couples of mesenteries. It was ascertained that in most meandroid Astræid corals linkage of stomodæa was indirect by means of interstomodæal couples, whilst in a genus like *Symphyllia* linkage of stomodæa was direct by means of mesenterial strands. The same collection provided material for an intensive histological study of the three layers constituting the soft parts of Astræid polyps revealing the syncytial nature of the ectoderm and endoderm and the fibrous and nucleated texture of the middle lamina comparable to connective tissue and suggestive of an incipient mesodermal condition. The histological structure, no less than the gross anatomy, particularly the nematocysts—their nature, distribution and relative abundance—furnished reliable taxonomic characters. This further led to a comprehensive study of all type material of Astræid corals preserved in the European and American Museums to assist in the revision of the two groups of Astræid corals—those possessing distinct corallites and the meandroid forms.

[1] The Zoological Survey of India, since its inauguration on 1st July, 1916, has been engaged in faunistic investigation, especially of lakes and estuaries, more than morphological or economic research. The first and the most important survey was of the brackish water of the Chilka lake and its island (Barkuda). The estuarine fauna of Goa in Portuguese India was studied for comparison with similar areas in lower Bengal. A study was also made of the fauna of the Mutlah river in the Gangetic delta which was found to be poor in species but rich in individuals, and seemed to show remarkable resemblance to deep-sea fauna (particularly in regard to colouration, translucency and in the possession of filamentous processes) although the river itself has a depth of only 4 to 8 fathoms. This resemblance was

[1] *Vide* Reports of the Zoological Survey of India, 1916–1935.

interpreted to be the result of convergent evolution brought about by certain factors common to both types of environment, such as muddy bottom and low visibility. Special attention was devoted to the study of the fauna of the Inlé Lake on the Shan Plateau. This lake, at the time of investigation, was about 14 miles long but comparatively shallow, being a 'Solution Lake' with a depth not exceeding 12 feet and muddy bottom. This lake was found to be characterized, like the Mutlah river, by abundance of individuals and paucity of species, its fish fauna being conspicuously coloured, the molluscs resembling those of deep water in several respects and also furnishing instances of variation in correlation with environment. Work was undertaken on the fauna in the environs of Calcutta, particularly of the river Hughli. A study of the geographical distribution of species was attempted along with their systematic position. A previous study of the faunas of the lake of Tiberias in Palestine, lake Biwa in Japan, the Tai-Hu in China and the Tale-Sap in Siam enabled a comparison to be made of them with the fauna of the Chilka lake. The animal societies in these different lakes seemed to show more of diversity than of resemblance.

A biological survey of the Indian freshwater molluscs and their Trematode parasites was undertaken with a view to determining the relation of the disease Bilharziasis or Schistosomiasis with any possible molluscan hosts, indigenous or otherwise, but the results were negative which showed that there was little or no risk of infection anywhere in India. In connection with this investigation a tour was undertaken to Seistan in East Persia where a study was also initiated of the aquatic fauna of the Hamun-i-Helmand which receives the river Helmand.

The aquatic and terrestrial fauna of the Punjab Salt Range was studied. An interesting investigation of cave fauna undertaken for the first time in India was that of the Siju Cave in the Garo Hills, Assam. Particular attention has been paid to the study of the fishes of hill streams in various parts of India and their structural and other adaptations to this peculiar environment. Special investigations with an economic bias have been made on behalf of Government, although in a limited sphere. An attempt was also made to study the freshwater fauna of the Andamans for a better understanding of the origin of such fauna and for comparison with the fauna of other lakes such as the Chilka lake. Attempts were also made to survey the fauna of some of the rivers of the North-west Frontier Province and of the back-waters of Cochin State. Since the Manchar lake in Sind and the back-waters of Vizagapatam were being subjected to considerable changes, the former by the establishment of the Sukhur Barrage and the latter by the construction of the harbour, a survey was made of the fauna of these changing waters. After the completion of the study of the fauna of the Chilka lake an

investigation was started of the fauna (and the Hydrogen-ion concentration) of the Nerbudda river which is peculiar in flowing from east to west. A survey was made of the Burma-Chinese Frontier in the upper Shan States (to enquire into the possibility of the spread of Schistosomiasis) and of the 'relict marine fauna' of the Indawgyi lake in Burma.

Fisheries research specially on *Trochus* was conducted in the Andamans, and results of both scientific and economic interests were obtained. Survey work was also attempted in Chitral and in the Eastern Ghats, the latter in conjunction with the Bombay Natural History Society. The investigation of the fauna of the brackish streams in the Salt Range in the Punjab and of their conditions of life have been of particular value. These streams are interesting since they begin as fresh water subsequently becoming saline. Similar investigation was undertaken of the waters of the Hughli which also change from fresh to saline. The faunistic study of the Indian backwaters to the north of Calicut and Bangalore was also undertaken. Work of this kind seems to have been undertaken for the first time in India in regard to inland waters.

[1] The study of higher Zoology at a University Centre in India seems to have started for the first time at Madras more than 50 years ago under A. G. Bourne and J. R. Henderson, and a paper on 'Notes on the Anatomy of Scorpions' was published in the Quarterly Journal of Microscopical Science as early as 1889. This pioneer attempt was helped by the Provincial Government by the establishment of a Museum with an important Natural History Section, of a Marine Aquarium, a Department of Fisheries, a Marine Biological Station at Krusadai, and latterly by the University in founding a Zoological Laboratory solely for research. Numerous papers have already been published by research workers at Madras dealing with several aspects of Zoology. With the opportunities afforded by an extensive sea coast and the facilities provided by the several zoological institutions, Madras promises to become a leading centre for research in Marine Zoology. Cytology also takes a prominent place in the programme of the Research Laboratory.

It was not till twenty years later that higher zoological teaching was started in Lahore under the direction of Stephenson. Since then a band of enthusiastic research workers have contributed not a little to the advancement of zoological knowledge, several of whom are at present holding responsible research posts in different parts of the country. Particular attention has been devoted to faunistic, morphological and cytological work by the school of Zoology at Lahore. Special areas have been selected for intensive study namely Lahore (terrestrial and

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[1] Based on information kindly supplied by the Heads of Zoology Departments in India.

freshwater), Karachi (marine), and Dal Lake in Kashmir Valley. Monographs on certain groups have already been published and others are under preparation. About the same time higher zoological research was started at Allahabad under Howlett followed by Imms and Woodland. Emphasis was laid at that University on Morphology, and recently on Cytology and Helminthology. Among the older Universities Bombay started higher teaching and research work in Zoology much later than Madras, Lahore and Allahabad, but with the establishment of a chair of Zoology at the Royal Institute of Science a fresh impetus has been given to zoological work, with the result that a school of Zoology has been rapidly growing up at that University, with particular attention given to the investigation of the littoral marine fauna of the Bombay Coast. At Calcutta where considerable research work in Zoology had been carried out under the auspices of the Asiatic Society of Bengal, the Indian Museum and R.I.M.S. 'Investigator', there was no organization for higher teaching and research in Zoology at the University itself till the establishment of a zoological laboratory in 1919. Since then there has been a remarkable output of research work, especially on Morphology, Embryology, Protozoology and Entomology. Research work in Vertebrate Embryology has been a remarkable feature of the school of Zoology at the Calcutta University.

Of the newer Universities Lucknow has taken the lead in zoological research work. The study of Oligochætes started by Stephenson at Lahore has been carried over to Lucknow, with emphasis laid on intensive morphological investigation especially of the excretory and blood vascular systems. The publication of several volumes of the Indian Zoological Memoirs has also been a noteworthy feature of the school of Zoology at Lucknow.

In Osmania University at Hyderabad, rightly famous for a successful experiment in imparting higher education through the medium of Urdu, the Department of Zoology has not lagged behind in contributing to the advancement of zoological knowledge. Higher zoological work at Bangalore was started at the Central College in 1911, the Department subsequently developing into the school of Zoology of the University of Mysore; research work has been undertaken on Morphology, more particularly on Amphibia. In the recently established Nagpur University special attention has been devoted to research work in Helminthology and Entomology. In the two all-India Universities namely, Benares Hindu University and Aligarh Muslim University, facilities have been provided for advanced zoological work. In the former special attention has been devoted to research work in Cytology and Cyto-genetics. The Aligarh Muslim University, noted for its extensive and well equipped zoological laboratories, has been engaged in research work mainly on Nematodes, the Ixodidæ and certain parasitic insects.

The future of our Science in India is secure in the hands of the enthusiastic zoologists working in different parts of the country. Its advancement will be still further enhanced by the establishment of a Department of Zoology at every seat of learning in India.[1]

[1] I am indebted to Dr. S. L. Hora for sending me in advance the following articles prepared for the Jubilee Session of the Indian Science Congress :—

'An outline of the fauna of India', by H. Srinivasa Rao.

'Outline of the progress of Zoology in India during the years 1914–1937', by H. Srinivasa Rao.

'Oceans round India', by R. B. Seymour Sewell.

# SECTION OF ENTOMOLOGY

*President*:—M. AFZAL HUSAIN, M.A., M.Sc., F.N.I., I.A.S.

# *Presidential Address*

## ENTOMOLOGY IN INDIA: PAST, PRESENT AND FUTURE.

CONTENTS.



## I. INTRODUCTION.

It is my very pleasant duty to extend, on behalf of the Entomologists in India, a most hearty and cordial welcome to our comrades from across the seas—the Delegates of the British Association for the Advancement of Science. In the development of entomology in India, the British Scientists have played a very important part. Let us hope that their association in our deliberations this year is yet another bond that will unite us still closer for rapid advancement of entomology and service to mankind. In our efforts to learn everything about insects and, through knowledge thus obtained, to bring them under control, we are engaged in one of the greatest and noblest of all undertakings, not for the benefit of a community, or a class of people, but for all humanity.

We must be happy that after 24 years of steady growth as a branch of zoology and in the service of agriculture, medicine and veterinary, entomology has established a claim for full independence. A similar status entomology has enjoyed in International deliberations since 1910, when the First International Congress of Entomology was held at Brussels, and within the Empire entomology has been 'self-governing' since 1920, when the first Imperial Entomological Conference was held in London. Having taken birth on the auspicious occasion of the Jubilee Session of the Indian Science Congress, the future success of this new Section seems assured.

I am deeply conscious of the honour done me in inviting me to preside over the first session of the Section of Entomology and I am equally conscious of the great responsibility that rests upon me, because does not the poet say :

> 'The first brick if a mason lays untrue,
> The wall to sky if built shall rise untrue.'

I have, therefore, attempted to trace briefly the history of Entomology in India, and have ventured to offer for your consideration, some suggestions for the future development of the science to which we owe allegiance : so that the first stone be laid well and true. It is an ambitious task and I am fully conscious of its magnitude. I, therefore, crave your indulgence.

## II. ENTOMOLOGY IN ANCIENT INDIA.

It is evident that man's association with insects dates back some 500,000 years, when our hoary ancestor hobbled clumsily on mother earth. His interest in insects was two-fold : they formed an occasional source of his food—spicy, crisp morsels, and 'they irritated him by day and disturbed his slumber by night'. It is certain that he must have adopted the simple method of 'hand-picking' to capture insects that formed his savoury food, and to rid himself of noxious vermin.

Coming to the period of which we have recorded history, we find the association between insects and man already well-established, mostly as bitter foes, though here and there as friends. The more ancient a civilization, the more closely interwoven this association. Hence India contests with China the claim of having domesticated the silkworm. It has been chronicled that in the year 3870 B.C. an Indian King sent as presents various silken stuffs to a Persian ruler. It must, therefore, be assumed that our forefathers were already well-versed in the manufacture of silk cloth, some 6,000 years ago (Bolle, 1917). They certainly knew how silk was spun by the silkworm, because Yajnavalkgasmati illustrates the creation of the world by God from Himself 'as the silkworm creates the cocoon from its own

saliva'. Our ancient sages must have made careful observations on the life-history and propagation of this insect before they were able to place the silk industry on a sound basis.

Similarly, lac has been 'cultivated' in India from prehistoric times. It has been in use both as a dye and as a resin for thousands of years. It is mentioned in the Mahabharata, in the Adi-Parva, that the Kauravas sought the assistance of Purochak—an architect of fame, to construct such a house as would destroy their enemy kinsmen the Pandavas. Purochak constructed a house of lac—a highly inflammable material (Misra, 1923). The Pandavas getting a timely warning, however, escaped the calamity.

References to honey-bee are very copious in ancient Sanskrit literature, honey being used as food and in rituals. It is interesting to find that the 'black-bee' was described as a stinging insect with six legs and given the name Ṣaṭ-pada—six legged (*Amarkosa*, 1st century A.D.), hundreds of years before P. A. Latreille (1825) invented the term Hexa-poda.

There is abundant evidence to show that ancient Indians devoted considerable attention to the discovery of the medicinal properties of insects. Undoubtedly this must have entailed careful researches and extensive and elaborate observations, continued over hundreds of years. There are also abundant references in ancient books of medicine to insect tormenters of man and various remedial and preventive measures have been suggested, some of which have survived to the present day. The use of *chauri*, now a mere symbol of dignity and regalia of royalty, must have originated as a measure of warding off the attentions of flies. And, burning incenses in temples, and during religious ceremonials, to please the deities, probably had its origin as repellents against mosquitoes and similar other insects seeking refuge in the dark, cool and humid interiors of the temples. We have frequent mention in Sanskrit medical works of the repellent properties of incenses and in *Matsyapurana* an incense so potent is mentioned that where it is burnt 'no insect will be seen there, neither frogs nor snakes'.

Calamities such as insect plagues have been regarded (and are still regarded among certain people), as manifestations of Divine wrath for the chastisement of man for his misdeeds. Visitations of lice, flies and locusts mentioned in Exodus came as punishments to the Pharaohs. The consequences of sin could only be averted through repentence and prayer, and therefore the aid of the priest became necessary in insect control.[1]

[1] Weiss (1937) has recently contributed an interesting article on 'Criminal Prosecution of Insects' in which he has given instances of certain law suits being instituted against insect pests and supernatural aid of Church invoked for their destruction. This went on even up to the 18th century.

There are hymns in Atharva-Veda [1] concerning the control of insect pests of crops, animals and human beings. Whether these methods of exorcism, sacerdotal conjuring and cursing were considered sufficiently potent or were employed as aid to more direct methods, we cannot say.

These hymns, however, give an insight into the variety of pests that had to be destroyed, the thoroughness of destruction that was aimed at, and the revenge which was contemplated against worms, providing abundant proof of the seriousness of the situation.

In Europe the scientific study of insects has been traced back to Aristotle (384–320 B.C.). It cannot be denied that long before his time Indian learning had reached a very advanced standard, but we are ignorant of the entomological observations of the Indian contemporaries of Aristotle, Pliny (23–79 A.D.) and others. Further researches in the ancient lore of our land may bring to light many facts of entomological interest. Observations about ants and their behaviour, salvaged by Moses (1928) from folk-lore, are an earnest of what remains to be discovered. One may commend such researches, in a field as yet completely unexplored, to some entomologically minded scholars of our classics.

[1] *Spells against worms* (from Atharva-Veda).

(1) The great mill-stone that is Indra's bruiser of every worm—with that I mash together the worm, as *khalva*-grains with a mill-stone.

(2) The seen, the unseen one have I bruised, also the *kururu* have I bruised; all the *algāndus* the *çalúnas*, the worms we grind up with our spell.

(3) I smite *algāndus* with a great deadly weapon; burnt, unburnt, they have become sapless, those left, not-left I draw down by my spell, that no one of the worm be left.

(4) The one along the entrails, the one in the head, likewise the worms in the ribs, the *avaskayá*, the *vyadhvará*—the worm we grind up with our spell.

(5) The worms that are in the mountains, in the woods, in the herbs, in the cattles, within the waters, that have entered ourselves—that whole generation of worm I smite.

(3) Like *Atri* I slay you, O worms, like *Kanva*, like *Jamadagni*, with the incantation of *Agastya* I mash together the worms.

(4) Slain is the King of the worms also the chief of them is slain, slain is the worm, having its mother slain, its brother slain, its sister slain.

(5) Slain are its neighbourers, slain its further neighbourers, also those that are petty as it were all those worms are slain.

(6) I crush up thy two horns, with which thou thrustest I split thy receptacle, which is thy poison holder,

# III. ENTOMOLOGY IN MODERN INDIA.

## TAXONOMY.

In so far as taxonomic entomology is concerned, its foundation was laid by Linnæus, and in the 10th edition of his 'Systema Naturæ' (1758), he included 12 Indian insects. During the next thirty years insect collections, made mostly by Christian Missionaries, had been sent to Europe, and Fabricius in his 'Entomologia Systematica' (1792–98) was able to include over 1,000 Indian species. Donovan's 'Natural History of Insects in India' was started in 1800. It was based on the collections of Francillon, Drury, MacLeay, Sir J. Banks and Donovan himself. Fabricius also had examined these collections. Among the collectors of the period prior to 1831 may be mentioned, among others, the names of General Hardwicke, Capt. Smee, Messrs. Saunders, Royle, and Downs. The second edition of Donovan's book, revised by Westwood was published in 1842, and Westwood's 'Cabinet of Oriental Entomology' appeared in 1847. These publications are unrivalled for the beauty of their coloured plates.

### *The Asiatic Society of Bengal.*

The Asiatic Society of Bengal was established in 1785 and under its auspices insect collections and knowledge about insects began to accumulate. The various publications of the Society contain much valuable entomological literature. Of the efforts made to encourage scientific enquiry and to disseminate scientific knowledge, those of Lord Auckland, patron of the Society about 1836, deserve special mention. He arranged informal social gatherings for the purpose and on the 9th November, 1836, for the first time, the Governor General's Conversazione was held and 'Natural Philosophy took its place among the social recreations of the Government house'. 'A very splendid collection of insects was seen displayed on the tables and against the walls, in convenient cabinets : the newest addition to these (which comprised a portion of Dr. Pearson's and of the Asiatic Society Cabinets) was the donation of Mr. George Loch of the Civil Service to the Asiatic Society at a recent meeting' (Journal Asiatic Society of Bengal, 1936). Incidentally this shows that insect collections were being presented to the Society early in its history.

All through the 19th century taxonomic study of Indian insects received a good deal of attention and the entomological publications of that period contain a vast amount of scattered information, mostly based on the collections made in India by enthusiastic foreign amateurs, and sent to specialists in Europe for identification.

The last quarter of the 19th century is, however, of very great importance in the history of entomology in India. It was during this period that entomological work began to be actually done in the country. The Indian Museum was established in 1875, the Bombay Natural History Society in 1883, and about this time, the 'Fauna of British India' began to appear. It was during this period that Ross was making history in Medical Entomology and the foundation of Agricultural Entomology was being laid by Cotes and others.

### *The Indian Museum, Calcutta.*

On the establishment of the Indian Museum, Calcutta in 1875, the entire collection of the Asiatic Society of Bengal was handed over to the Museum. Cotes (1896), however, informs us that, 'unlike the other portions of the Indian Museum the Entomological Section did not receive any large contingent of specimens from the Asiatic Society of Bengal', and that 'it was not until Dr. Anderson (1865–1886) was appointed Curator that any persistent attempt seems to have been made to gather together representatives of the general insect fauna of India'. Cotes tells us that previous to his appointment in 1884 the insect collection was under the care of Wood-Mason, Nevill and de Niceville, and it consisted mainly of the specimens collected by de Roepstorff from the Andaman and Nicobar islands, by Wood-Mason from Andaman and Cachar, by Peal from Assam and by Young from Kulu. Dr. Ferdinand Stoliczka had bequeathed to the Museum a considerable collection of Rhynchota. Lionel de Niceville's set of butterflies was the finest that the Museum possessed. There were some named Indian Coleoptera, in a bad state of preservation, which had been received from the Museum of the East India Company in London. There was a fine series of the Mantidæ collected and named by Wood-Mason and a few Phasmids. There was also a miscellaneous collection made by Indian collectors employed by the Museum in various parts of India.

Cotes (1896) states that in 1884 the number of specimens in the Museum was less than, 20,000. The next decade saw rapid growth and by 1894 this collection was four-times richer in specimens. At the same time it had been sorted and classified. Cotes left in 1896.

Lionel de Niceville, who had been collecting butterflies for years, was appointed to the newly created post of Entomologist to Government of India in 1901, and put in charge of the section of Entomology at the Museum. Unfortunately he died in December 1901, and after his death the post of Entomologist to Government of India was transferred from the Museum to the Agricultural Department. All Entomological work at the Museum remained practically in abeyance until 1909 when a

new post of Assistant Superintendent in Entomology was created and F. H. Gravely appointed. He did valuable taxonomic work on certain families of the Coleoptera. Gravely was transferred to Madras in 1920. The post remained vacant up to 1923, when B. N. Chopra was appointed and on his transfer to another Section of the Museum, H. S. Pruthi took over charge of the Section of Entomology in 1925 and held it till 1934. He contributed to the taxonomic studies of the Jassidæ. Pruthi was appointed Imperial Entomologist to the Government of India, and his place at the Museum taken by Hafiz. Sharif, who held a temporary appointment in the Zoological Survey produced valuable work on fleas. The section has always remained a small one with just one Assistant Superintendent and a few Assistants.

From its very inception the Indian Museum, Calcutta has been a centre of systematic work on insects, and has today a collection of insects containing over 17,000 named species. This collection has been built up with the help of the Indian Museum staff, and collectors working in several parts of India, as well as by purchase of private collections and donations from amateurs. Among such amateurs was Lord Carmichael (Ex-Governor of Bengal) who donated a huge collection to the Indian Museum. Many of the staff of the Museum and of the Zoological Survey (established in July, 1916) were interested in entomology and have added to our knowledge of taxonomy.

The co-operation of entomologists in different parts of the world for working the Indian Museum collections had been obtained very early, and European and American entomologists have been closely associated all along with the development of taxonomic entomology in this country.

The Records and Memoirs of the Indian Museum contain much valuable material on insect taxonomy.

### *The Bombay Natural History Society.*

The Bombay Natural History Society was founded in 1883. The members of this Society have done, from the very beginning, valuable work in entomology, particularly taxonomic entomology. The Society started the publication of a Journal in January, 1886. Much entomological literature has appeared in this periodical.

The Society commemorated its Golden Jubilee in 1933, and printed a very interesting and illuminating account of the entomological work done in India by its members.

Of the various groups of insects, butterflies have been most extensively collected and studied. Of the earliest writers and collectors of butterflies are Wood-Mason (1875–1881), Col. Swinhoe (1884), Moore (1884), and Watson (1890). Lionel de Niceville (1881–1902) and Marshall are the founders of systematic

work on Butterflies in India. Lionel de Niceville's three volumes on Butterflies had appeared between 1882–1890, the 4th volume in manuscript was purchased by the Indian Museum and placed at the disposal of Bingham who was preparing the Fauna volumes on Rhopalocera.

Bell (1896–1910) studied the life-histories of Indian Butterflies.

Of the other workers who have contributed to our knowledge of the Indian Butterflies Doherty (1889–1891), Mackinon (1896), Mrs. Robson (1895), Leslie (1903), Young (1904), Rhe Philipe (1906–1917), Andrewes (1909–1911), Betham (1909), Hannyngton (1911), Tytler (1915), Allen (1919), Ollenbach (1919), Yates (1930), Peile (1937), and Puri (1930) have done good work.

Sir George Hampson's (1888–1910) name is familiar to all students of Indian Heterocera as the author of the four volumes on Moths in the Fauna of British India. Dudgeon (1895–1906) has also described many Indian Moths. Fellows-Mansion has done good work on Sphingidæ, while Prout (1928) has published much on Geometridæ.

Meyrick's (1908–1913) work on Microlepidoptera is of outstanding merit. Fletcher's studies on the life-histories of Indian Microlepidoptera are valuable additions to our knowledge of the group.

Of the early writers on Indian Coleoptera the name of Baly (1886) stands out prominently. Little work on Indian Coleoptera appears to have been done up to 1910, when Maulik published his admirable work on Chrysomelidæ. Gravely (1913–1923) has done good work on Tenebrionidæ and Passalidæ. Gardner has done pioneer work on the systematics of the larvæ of Coleoptera. The list of present day workers on Indian Coleoptera include such familiar names as Arrow, Andrewes, Blair, Marshall and Ochs.

The first worker on Indian Hymenoptera is Wood-Mason (1875–1881). He was followed by Forel (1885–1902) who has done excellent work on Indian Formicidæ. The best work on Hymenoptera, however, is by Bingham (1888–1908) whose collections form the basis of his Fauna volumes on the Order. Nurse (1903–1914) who collected in Baluchistan and Simla also made valuable contributions to this order. Lately he presented his collections of 10,000 Hymenoptera to the British Museum.

Other workers on the group are Cameron, Turner, Hingston, Mani, Wroughton, Rama Krishna Ayyar and Uani. Mukerji, Negi, Misra and Gupta have studied the ants and the three latter in relation to the lac insect.

Giles in 1900 contributed a paper on Mosquitoes and Malaria to the Journal of the Bombay Natural History Society. This was followed by descriptions of some new species of mosquitoes by Cogill. It was, however, Theobald who wrote regularly

on Indian Culicidæ between 1906–1910. Recently Barraud and Christophers have written Fauna volumes on Indian Culicidæ. Other workers who have contributed to our knowledge of Malaria and Mosquito are Liston, Bentley and Covell. Russell has published a series of useful papers on Parasitic Diptera. Sinton has worked on the sandflies and Mitra on Culicoides. Brunetti (1907) wrote a number of papers on Diptera and published the Fauna volumes on the group. Important contributions to our knowledge of Diptera have also been made by Keiffer (1909), Bezzi (1913), Cross (1926), Edward (1932), Isaac, Bhatia and Puri.

Aitken (1884–1889) and Kirkaldy and Kershaw (1909) are the earliest writers on Indian *Rhynchota.* They were followed by Distant who wrote the Fauna volumes on Hemiptera. Green (1899) studied Coccidæ—a group of great economic importance and his 'Coccidæ of Ceylon' contains material of much value to Indian students. Karagode, Rama Krishna Ayyar, and Mahdi Hassan have also made valuable contributions to this family. Pruthi has studied Jassidæ. Das (1915) worked on the Aphididæ of Lahore, while Krishna Murti is studying the Aphididæ of Mysore. Crawford (1912) has done work on Psyllidæ and Maskell, Peal, and Lamba on Aleurodidæ.

Liston (1904) studied fleas in relation to plague. Gragg and Sharif have made systematic study of Siphonaptera.

Laidlaw (1911) started the study of Odonata and Fraser made an intensive study of Indian Dragonflies, his three Fauna volumes providing a splendid study of the order.

Wasman wrote on the Termites in 1889. Assmuth took up this work but did not complete it. His collection was later described by Holmgren. Later on Fletcher also made contributions to this very important group. Dr. Anandale also interested himself in Termite Mounds.

Wood-Mason (1875–1881) laid the foundation of the study of the order Orthoptera by his work on Phasmidæ and Mantidæ. Cotes studied the locust, *Acridium peregrinum* in 1899. Of recent workers on the order names of Giglio Tos (1914), Chopard (1911) and Uvarov deserve special mention.

Bagnall (1912) and Rama Krishna Ayyar have studied Thysanoptera.

Our knowledge of Dermaptera we owe to Burr, of Trichoptera to Dover and Uartynow, of Neuroptera to Needham, of Thysanura to Silvestri and of Collembola to Carpenter.

### *Number of species of insects known from India.*

Blanford in 1881 put down the number of species of insects known from this country at 12,100; Lefroy (1909) attempted a similar census 28 years later and raised the figure to 29,700; in 1917 Fletcher put it at 35,000. On the basis of the information

contained in the 'Lists of publications on Indian Entomology' (1920–1934), it is estimated that over 5,000 new species have been described since 1917. It will, therefore, be safe to estimate that by now the species of Indian insects known number 40,000.

As to the number of insect species actually existing in India there has been a gradual rise in estimates. Cotes estimated twenty thousand to be a moderate computation, Fletcher (1919) raised this figure to 70,000. Sharp (1919) stated—'that no more than one-fourth of the insects existing in India are represented in any collection or even in all the collections if they could be united and brought together in one'.

The number of the existing species of the insects of the world has been variously estimated at 2·5 millions to 10 millions and the latter figure is certainly nearer the truth. India's share of the variety of insect forms cannot be less than 25 per cent. of the world's and that will bring the figure to 2·5 millions. On this basis, of the insects of our country we know only one for every sixty we know not. If the estimates of Blanford, Lefroy and Fletcher were correct then during 1881–1917 additions to the number of the species described were being made at the rate of 640 per annum, while during the last twenty years it has been about 250 per year.

### *Our Insect Collections.*

Although we may claim that insect collecting in this country has gone on continuously for over a century and a quarter, yet the condition of our collections is unfortunately distressing. Our main general collections are at the Imperial Agricultural Research Institute, New Delhi, the Indian Museum, Calcutta, and the Forest Research Institute, Dehra Dun. There are also the collections of the Bombay Natural History Society and those of the various Medical Institutes, provincial Agricultural Colleges, some provincial Museums, local societies and some of the Universities.

Through the courtesy of the officers in-charge, I have obtained figures regarding the present condition of the three of the first named collections (see statement below). From the information available it is estimated that the number of known species in all the collections in India does not exceed 25,000. This number is 10,000 short of Fletcher's estimate of 1917 and 15,000 short of the computation now made.

Taking a few specific instances we find the position very disappointing. Distant (1902–1918) described 4,005 species of the Rhynchota (he did not deal with the Psyllidæ, Aphididæ, Aleurodiadæ and Coccidæ), but in all the main collections in India we have not more than 1,600 species represented. Thus, of the Rhynchota of our own country, all our collections put together, do not contain more than 33 per cent. of the species

*Approximate number of species of Insects in different collections in India.*

| | Imper. Agri. Res. Inst., New Delhi. | Ind. Museum, Calcutta. | Forest Res. Inst., Dehra Dun. | Estimated number in all collections in India. |
|---|---|---|---|---|
| Hymenoptera .. | 1,000 | 1,397 | 600 | 1,450 |
| Diptera .. | 2,500 | 3,236 | 400 | 3,500 |
| Lepidoptera .. | 8,000 | 6,068 | 3,300 | 8,750 |
| Trichoptera .. | .... | 140 | .... | .... |
| Coleoptera .. | 5,000 | 3,617 | 7,000 | 7,500 |
| Rhynchota .. | 1,500 | 1,575 | 1,000 | 1,600 |
| Neuroptera (Sensu-antiquo) .. | .... | 162 | 250 | 260 |
| Orthoptera (Sensu-antiquo) .. | 1,500 | 1,193 | 300 | 1,700 |
| | 14500 | 17,39[illegible] | TOTAL .. | 24,760 |

*Types of Indian Insects.*

| | No. of spp. described. | Types in India. | | Types outside India. | | Types unaccounted for. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | Indian Museum. | Pusa Collection. | British Museum. | Other foreign museums. | | |
| FAUNA OF BRITISH INDIA. | | | | | | | |
| 1. *Coleoptera.* | | | | | | | |
| (i) Chrysomelidæ (Maulik) 1919, 1926, 1936 (3 volumes) .. | 1,157 | 24 | 1 | 675 | 364 | 111 | |
| (ii) Lamellicornia (Arrow) 1910, 1917, 1931 (3 volumes) .. | 1,041 | 9 | .. | 446 | 477 | 109 | |
| (iii) Carabidæ (Andrews) 1929, 1935 (2 volumes) .. | 494 | 17 | .. | 177 | 283 | 17 | |
| 2. *Hymenoptera* (Bingham) 1897, 1913, Vols. I, III. .. | 1,405 | 17 | 19 | 139 | 254 | 976 | |
| 3. *Odonata.* (Fraser) 1933, 1934, 1936 (3 volumes) .. | 536 | 37 | 1 | 117 | 292 | 81 | For. Res. Inst. D. Dun, 3. Darjeeling, 5. |

which were known from India by 1918. Let us take another instance. Fraser (1933–1936) deals with 536 species of the order Odonata in his three volumes of the Fauna of British India, and we have no more than 260 species represented in all the collections of our country, and of the types we have but 46.

It is only comparatively recently that work on Odonata was started. Of the Chrysomelidæ, Lamellicornia and Carabidæ, 2,692 species have been described in eight volumes of the Fauna of British India (1910–1936) and of these we have only 51 types in India. Of 1,982 species of the Hymenoptera included by Bingham, in his two volumes of the Fauna (1897–1913) we have only 36 types in our collections. (See statement above.)

For comparison let us study the figures for North America (Hinds, 1934). In 1932, the number of insect specimens at the National Museum of Washington was 4 million and there were 170,000 named species and 50,000 types. The Canadian Museum at Ottawa had 800,000 specimens, including 30,000 named species and 4,000 types.

The slow pace at which taxonomic work has gone on in India may be judged from the following specific instance. The Aleurodidæ are of considerable importance as pests of crops and fruit trees. Maskell, the first to study Indian Aleurodidæ, described 5 new species in 1895. Peal, 8 years later (1903) added 7 more species from India. About that time rapid progress was being made in America and Quaintance had, by 1909, listed some 160 species, and since then many more have been added. In India it was not till 1931 that Lamba made a study of this family and recorded 44 species (not including 17 already described) of which 25 were new to science. Lamba's work was based on the material collected mainly from the Pusa Estate—an area of a few square miles. An investigation carried out over the entire country will show that perhaps ten times as many more species still remain undescribed as have been described so far.

Of course there are some groups which have received greater attention than others. Mosquitoes for instance, because of their medical importance, have been collected and studied very intensively. Till about 1890 only four species of mosquitoes were known from India, but by 1917 over 200 species had been described (Fletcher, 1917), and within less than 20 years Christophers (1933), and Barraud (1934) described 315 species of Culicidæ in the Fauna of British India. Again, while in 1889 Cotes and Swinhoe catalogued 225 species of the Microlepidoptera, by 1917, i.e. within less than thirty years, well over 2,000 species had been described from India (Fletcher, 1917). These instances show what amount of work remains to be done in every group of the class Insecta.

## PUBLICATIONS ON SYSTEMATIC ENTOMOLOGY.

### *The Fauna of British India.*

Hampson's four volumes of the Fauna of British India on Heterocera (1892–1896), followed by a volume on wasps and bees (1897) by Bingham appeared during the last decade of the 19th century. The remaining 38 volumes, so far published, came out during the twentieth century, and as many as eleven volumes during the last seven years. Some of the early volumes are already out of date. A large number of orders has not yet been touched at all.

India owes a deep debt of gratitude to those British entomologists who have contributed towards this valuable record of Indian Insects. Lately, it is gratifying to note, some Indian entomologists have come forward to take their share in this national work. Maulik's volumes on Chrysomelid beetles have maintained the high standard of the series, and we are glad to see it announced that Sharif has been selected for the task of preparing volumes on fleas, lice and ticks. Let us hope that more and more of this work will be entrusted to indigenous talent, and more and more of our young entomologists will qualify to take such work in hand.

### *Catalogues of Indian Insects.*

An insect catalogue is the dictionary of an entomologist and also his directory. At present in most cases we do not know what we possess and where it is ? Without catalogues no taxonomic work is possible. Cotes when attempting to arrange the collection of moths in the Indian Museum felt the need of a catalogue. He commenced this laborious task and Col. Charles Swinhoe, who had amassed through his long service in many parts of India, one of the largest of amateur collections of Indian moths in existence, came to his help. After three years of hard labour the catalogue of moths was completed, and the Museum specimens arranged. Similarly, the work of arranging at the Indian Museum collections of different groups was taken up side by side with the work of cataloguing. Catalogue of Rhynchota by Aitkinson is one of the earliest attempts.

Catalogues, check lists, and similar other publications have appeared from time to time in the publications of the Asiatic Society of Bengal, the Indian Museum and the Zoological Survey, the Journal of the Bombay Natural History Society, the Indian Journal of Medical Research and various publications of the Imperial Department of Agriculture, and other periodicals but the credit of making a most organized attempt to publish a series of the Catalogues of Indian Insects goes to Fletcher. He placed this matter before the 3rd Meeting of the Entomologists in 1919, and his proposal received unanimous support. Government

sanctioned expenditure on these publications and the entomologists came forward to help. The first part of the Catalogue of Indian Insects was published in 1921. So far 23 parts have appeared and a few more parts are ready for publication. Of these Fletcher himself was responsible for 6 parts. However, up to date, not more than 25 families have been dealt with, the total number of families recognized by Fletcher (1926) being 495. This just shows how far we have lagged behind in this work, and what tremèndous concerted and co-operative efforts we must make in this direction.

In the past much valuable taxonomic work has been done by amateurs, staff of the Indian Museum (now Zoological Survey of India), medical entomologists and the entomologists in the Agriculture and Forest Departments.

### *Pure Entomology—other aspects.*

Exceedingly little work has been done in India on other aspects of pure entomology in general. It is only recently that the teachers at the Universities and their post-graduate students have selected entomological subjects for research. Mukerji and his pupils from Calcutta, George and his pupils from Bombay, Misra and his students from Benares, students of the Zoology Schools of Lahore, Lucknow and Aligarh have made valuable contributions. Vishva Nath from Lahore, Asana from Gujarat (Sind) and Bhattacharya from Allahabad have selected insects for their cytological work.

## Applied Entomology.

### Agricultural Entomology.

#### *Indian Museum, Calcutta.*

The first Institution that undertook applied work side by side with taxonomic work, was the Indian Museum, and till the close of the 19th century the Museum continued to be the centre of all research and information on Indian insect pests. Wood-Mason (1884-85) carried out investigations on the *Tea bug* and *Tea mite* of Assam on *Paraponyx oryzalis*—a pest of rice in Burma. He answered enquiries about noxious insects and their control, addressed to him from all over the country. In 1888 Cotes undertook investigation on the wheat and rice weevils of India, and soon after the Trustees of the Indian Museum officially took upon themselves the responsibility of investigations on crop pests of India as a part of the work of the entomological section of the Museum. Circular letters inviting co-operation of officials and others resulted in the accumulation of a large quantity of material and information, particularly from the Provincial Departments of Land Records and Agriculture.

Cotes published the results of his investigations on applied entomology in the first three volumes (1884–1896) of the Indian Museum Notes—a publication specially started for the purpose. Cotes left the Museum in 1896 and the subsequent two volumes (1900, 1903) of the Indian Museum notes were compiled by Barlow (who died in 1900) and Peal.

Rapid increase in Entomological work and demand for a proper study of crop pests necessitated the creation of the post of Entomologist to Government of India. In January, 1901, as has been stated above, Lionel de Niceville was appointed to this post with headquarters at the Indian Museum. He was required to make observations on the crop pests in the field and in actual areas of their occurrence. He visited Darjeeling to study the Mosquito Blight of Tea, contracted fever and died of it in December, 1901. E. P. Stebbing officiated as Superintendent of the Indian Museum for sometime during 1903 and he published Part I of the sixth volume of the Indian Museum Notes. This was the last publication on Economic Entomology from the Indian Museum.

### *Imperial Agricultural Research Institute, Pusa.*

H. Maxwell Lefroy succeeded de Niceville as Entomologist to Government of India in 1903 and was stationed at Surat for the study of cotton pests. In 1905, when Lord Curzon reorganized the Department of Agriculture, a Central Agricultural Research Institute was started at Pusa and Lefroy transferred there as Imperial Entomologist to the Government of India. Lefroy came to India as a young man, 'insistent and forceful', full of enthusiasm and energy. He set out to build a collection, studied the life-histories of insects, and devised control measures against insect pests. The progress made by him and his co-workers was indeed phenomenal. Three years after his arrival in India Lefroy published his most useful book 'Indian Insect Pests' (1906), and after another three years his classical work on Indian Entomology 'Indian Insect Life' (1909), [unfortunately now out of print], covering 786 pages, containing 536 diagrams and 84 beautiful coloured plates. This book is a monument to the knowledge, energy and industry of Lefroy and his co-workers of that period.[1] In 1912, Lefroy left India, though fortunately he was not lost to Indian Entomology. At the Imperial College of Science and Technology he trained a number of Indian Entomologists and his deep interest in India and her Entomological problems continued. He visited India again in 1915-16 and wrote a comprehensive report on Sericulture. Those who have had the privilege of working in his laboratory at the Imperial

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[1] Misra, Ghosh, Dutt, Naoroji.

College of Science would remember his contagious enthusium for entomology. Lefroy was associated in his work by Howlett, a man of brilliant intellect and charming personality, an original thinker and an excellent artist. Howlett joined as Second Imperial Entomologist in 1907 (in 1912 the designation of the post was altered to that of Imperial Pathological Entomologist). Howlett died in August, 1920.

T. Bainbriggs Fletcher joined in April, 1910 as Supernumerary Entomologist and was transferred to Madras as Entomologist to Government in April, 1912. He returned to Pusa in December, 1913 as Imperial Entomologist and held that post till 1932. During his time insect taxonomy received the greatest attention at Pusa and he built up a splendid library and a valuable collection particularly of the order Lepidoptera.

C. W. Mason (1912) joined as Supernumerary Entomologist and during his short term of service he did valuable work on the birds of Pusa. (Mem. Dept. Agric. India, No. 3.)

Howlett's place was taken by Isaac in June, 1922 as Second Entomologist (Dipterist).

Fletcher (1917) submitted to the Indian Industrial Commission of 1916–18 an elaborate scheme to set up a Central Organization for all pure and applied work including medical, veterinary, agricultural and forest entomology, in India. This Bureau was to consist of 20 expert entomologists, 23 Entomological Assistants with necessary staff. The non-recurring expenditure on building, etc. was estimated at about Rs.14,00,000 and the annual recurring expenditure at Rs.4,41,900. The Industrial Commission gave their support to the scheme, but because of the changes in the organization of the administration of the country, by which Agriculture, Medicine and Veterinary became transferred subjects under the Provincial governments, and partly because of the magnitude of the scheme, it did not receive consideration from Government.

Fletcher's place as Imperial Entomologist was taken by Hem Singh Pruthi in 1934.

During the last 30 years or so several thousands of Indian insects have been reared in the Insectary of the Imperial Agricultural Research Institute at Pusa and illustrations, mostly coloured, of their life stages made. Several monographs on the life-histories of the more important groups—for example, Microlepidoptera, Hymenoptera, Coleoptera, Diptera, etc. have been published. Considerable amount of research work on several serious pests of Indian crops has been conducted. Boll-worms of cotton, Borers and Hoppers of sugarcane, pests of fruits, etc. etc. have been studied. Investigations on Termites, stored grain pests and insectivorous birds have also been undertaken. The results of these investigations have appeared as Memoirs of the Department of Agriculture in India and Bulletins of Agricultural Research Institute, Pusa.

## *Agricultural Entomology in the Provinces.*[1]

It was in 1905 that Mr. Sly in his proposals for the development of Agriculture provided for a qualified Entomologist in each province. The Secretary of State for India, however, negatived this proposal. In 1909 there were only 13 Entomological Assistants in the provinces, by 1910 this number had increased to 16—5 for teaching and 11 for field work. It was not till 1912 that a Government Entomologist was appointed in Madras, the Punjab followed in 1919 and the U.P. in 1922. In these three provinces Entomological work developed and expanded. A class II Officer was appointed in Nagpur in 1931 but the section is yet a one man show. Bombay, Bengal, Bihar, Orissa, Assam, Sindh, North-West Frontier Provinces, and Baluchistan still continue to have a very small staff of Assistants for pest control.

In Madras the Entomological work was started in 1902-03 with one Upper Subordinate who worked under the Economic Botanist. This arrangement continued till 1908-09 and by then the number of Upper Subordinates had increased to three. In April, 1912 Bainbrigge Fletcher was appointed Government Entomologist, Madras. Fletcher was transferred to Pusa in December, 1913 and E. Ballard appointed Government Entomologist in January, 1914. On Ballard's retirement, Rama Chandra Rao was appointed Entomologist to Government, Madras, and held this post till December, 1930, when he took over as Deputy Locust Research Entomologist in the Locust Research Scheme of the Imperial Council of Agricultural Research. He was succeeded by Rama Krishna Ayyar, who retired in July, 1935. This veteran entomologist continues to take keen interest in entomology. Cherian is now officiating as Entomologist.

In 1914 Fletcher published his book on 'Some South Indian Insects' and brought together all the available information on South Indian insects and other crop pests, with useful chapters on applied entomology.

Entomological work was started in the U.P. as early as 1906 with the appointment of one Assistant, placed under a Deputy Director of Agriculture. A regular Entomological Section was created in 1921 and P. B. Richard appointed Entomologist to Government. The main problem of the Entomological Section has been the control of Pink Bollworm. For this investigation the Indian Central Cotton Committee gave, during the years 1922 to 1934, a grant of Rs.1,46,731.

The Entomological Section in the Punjab came into existence in 1905, and was placed under the Government Economic Botanist, Lyallpur. An Assistant Professor of Entomology was

[1] Based on the information kindly supplied by workers in the provinces.

appointed in 1908 but it was in 1913 that the Section became independent under Madan Mohan Lal. Till 1919 the staff consisted of one Assistant Professor of Entomology and three Agricultural Assistants. In September, 1919 M. Afzal Husain was appointed Entomologist to Government, Punjab. Since 1919 the Entomological Section has grown steadily and at present the staff consists of the Government Entomologist, one Assistant Entomologist, two Assistant Professors, two Research officers (one on Cotton Research Scheme financed by the Indian Central Cotton Committee) and 34 Research Assistants.

Perhaps Baluchistan was the first province where applied entomology received attention. James Cleghorn in 1890 contributed an interesting article on the melon fruit fly of Baluchistan —*Carpomyia pardalina* Bigot. The Government of Baluchistan invited Stebbing to study the borers affecting the shade and fruit trees in Quetta. In 1914 the Imperial Department of Agriculture established a Fruit Experimental Station at Quetta. However, it was not till 1932 that the Agricultural Department was organized in Baluchistan and a small Entomological staff sanctioned.

*Entomological work in Indian States.*

Of the Indian States, Mysore was the first to employ an Entomologist. In fact Coleman was appointed Entomologist and Mycologist in 1908 before Entomologists had been appointed in any of the provinces of British India. When Coleman was appointed Director of Agriculture, K. Kunhi Kannan, who had been associated with Coleman in his work, was appointed Entomologist and was given a staff of three Assistants. The Entomological Section of Mysore continues to maintain its tradition of useful work.

Kashmir, well known for its apples and pears, is the best locality in India for hilly fruits. Till as late as 1913 no attention was paid to insect pests of Agricultural and Horticultural importance. During this year, Ram Gopal, the then Director of Agriculture and Horticulture, discovered San Jose' Scale playing havoc with fruit. By 1921 this pest and the Woolly Aphis had been definitely identified. In 1923 the State obtained the services of Fletcher who studied the San Jose' Scale. It was in 1930 that a small Entomological Section was inaugurated.

Lately investigations have been started in Hyderabad-Deccan on the Pink Bollworm of Cotton, financed by the Indian Central Cotton Committee.

*Work done in the Provinces and States.*

Although some systematic work on Curculionidæ, Coccinellidæ, Parasitic Hymenoptera, Thysanoptera, Syrphidæ, and

Coccidæ has been done in Madras, the Provinces and the States have been mainly devoting their attention to the study of insect pests. Of the insect pests the following have received special attention :—*Hieroglyphus banian* Fb., *Colemania sphenaroides* Boliv., *Hispa armigera* Oliv. *Pempheres affinis* Fet., *Aulacophora abdominalis* F., *Trogoderma khapra* Arr., *Calandra oryzæ*, Linn ; *Schænobius bipunctifer* Wlk ; *Spodoptera mauritia* Basl, *Phthorimæ opercullela*, Zell, *Earias* spp., *Platyedragoss ypiella*. Saund., *Scirphophaga nivella* Fb. *Argyria sticticraspis*, Hampsn. *Pachydiplosis oryzæ ; Chætodacus zenatus* F., *Carpomyia vesuviana*. Bigot., Termites ; *Leptocorisa varicornis*. F., *Pyrilla* spp., *Idiocerus* spp. *Diaphorina citri* Kuw., *Aleurodidæ ; Eriosoma lanigerum* Haus. and other Aphididæ, *Aspidodiotus perniciosus* Comst. and other Coccidæ ; and *Thrips tabacci*, Lind. In addition, these Provinces and States have also been organizing control measures against pests. Recently the Punjab has started (with a special staff of three Assistants, the strength to be increased to 6 next year) a Plant Protection Service for undertaking large scale control operations, thus separating the Research and the Field staff.

The Biological control of insects has also been receiving attention. While the Punjab and Madras have studied the parasites of *Rephantis serinopa* and *Earias* spp. respectively, Mysore has been carrying out mass production of *Trichogramma*.

The Punjab has also done considerable amount of work on the feeding habits of birds.

Further, such useful industries as sericulture, lac culture and apiculture have been receiving their due share of attention from the Imperial Institute of Agricultural Research, Provincial and State Entomologists. In all cases efforts have been and are being made to encourage these cottage industries.

### *Indian Central Cotton Committee and Entomological Research.*

The Indian Central Cotton Committee was established in 1921 and since then many research schemes dealing with insect pests of cotton have been financed by this body. Particular mention may be made of the Pink Bollworm investigations in the Punjab and the United Provinces, the Spotted Bollworm investigations in Surat and the Punjab, the White-fly investigations in the Punjab, the *Pempheres* investigations in Madras and the Jassid investigations in the Punjab. The Indian Central Cotton Committee has so far spent over Rs.10,30,000 on Entomological Research and control of cotton pests.

In the training of Indian Entomologists the Indian Central Cotton Committee has played a very important part. Since 1922, 11 post-graduate scholars have received training in India and abroad at an approximate cost of Rs.50,000 to the Committee.

### *Imperial Council of Agricultural Research and Entomological Research.*

The Imperial Council of Agricultural Research was set up in 1929, to initiate and co-ordinate Agricultural Research on an all-India basis. It has financed various schemes of Agricultural interest costing over 85 lakhs of rupees, of which the entomological schemes had a share of Rs.7,60,450.

The very first problem which the Council took up was that of the Desert Locust—an ancient scourge of many lands. The Locust Research Scheme was started in 1930. M. Afzal Husain was in charge of the scheme as Locust Research Entomologist for 1930–1933, and was succeeded by Rama Chandra Rao in April, 1933. A portion of the staff worked on the life-history and bionomics of the Desert Locust at Lyallpur and the rest formed survey parties to determine the breeding grounds of the pest in Baluchistan, Sind and Rajputana, with headquarters at Quetta. In 1933 the scheme was divided into two parts. The headquarters of the survey portion were shifted to Karachi while the bionomics and phase problems were continued to be studied at Lyallpur. The Council has already spent about 5 lakhs of rupees on this scheme and as Sir John Russell has remarked, the results achieved are of outstanding value. A number of papers have been published. As a result of this investigation much valuable knowledge has been gained and it is certain that locust cannot be upon us without a warning, and besides, with the knowledge we possess today, warfare against this pest will be brought to a successful termination, speedily and economically.

The other important investigation under the aegis of the Imperial Council is that on the Sugarcane pests. A sum of 96 thousand rupees has been allotted for this work which is being conducted by Issac at New Delhi, with sub-stations at Karnal, Pusa and Coimbatore. Parasites of these pests are being collected with a view to investigate the possibilities of biological control.

The San Jose' Scale, an introduced pest, has spread in the submontaneous tracts of the Punjab and N.W.F.P. and has established itself in Kashmir and other fruit growing localities. The Council have initiated, under Khan A. Rahman, a survey to ascertain the distribution and incidence of San Jose' Scale and other fruit pests. A survey of Codling-moth in Baluchistan has just been concluded by the Imperial Entomologist (Hem Singh Pruthi). A scheme to determine insecticidal value of plant fish-poisons was sanctioned in 1935 at a cost of Rs.15,288 at Bangalore. A scheme for the investigation of *Pachydiplosis oryzæ* has been financed, at Nagpur.

In addition to these exclusively entomological investigations, insect-life is being studied in several of the other schemes run by

the Imperial Council. The Fruit Research scheme at Chaubattia (U.P.) has an entomologist making a tree to tree survey to determine the incidence of pests and to correlate this with soil conditions. Entomological workers are associated with sugarcane investigations in various provinces.

## *Indian Tea Association.*[1]

Tea has always suffered from ravages of various insect pests to which Mann drew attention in 1903. It was not, however, until 1905 that an Entomological Laboratory was established at Kannykorrie (Assam) in charge of C. B. Antram. In 1911 Antram resigned and E. A. Andrewes succeeded him. Entomological work was transferred to Tocklai in 1913. Life-history of important pests of tea and their control measures have received attention. Andrewes made a very exhaustive study of *Helopeltis theivora*—'Tea Mosquito'. On account of financial world-depression the Entomological staff was reduced and Andrewes resigned his appointment in 1932. Similarly the United Planters Association of Southern India, in their Tea Scientific Department which was organized about 12 years back, undertook work on insect pests. It was about 1932 that they appointed an Entomologist. Besides *H. Theivora* the following pests of tea have received attention:—red spider *Tetranychus bioculatus*, Limacodid grubs, which have come into prominence lately, *Homona coffearia*, *Xyleborus fornicabis*, termites, *Toxoptera amantii* and a few others.

## *Lac Association.*

Researches on lac were conducted at Pusa by C. S. Misra, and at Dehra Dun by A. D. Imms and N. C. Chatterjee; and A. B. Misra shared his father's enthusiasm and also did valuable researches on the lac insect.

The Government of India appointed a Commission in 1921 to report on the condition of lac cultivation and as a result of their recommendation established in 1925 the Indian Lac Research Institute at Ranchi with (Mrs.) Dorothy Norris as the first Director. On her retirement Sen was appointed Director.

The Institution is engaged in finding out the improved methods of cultivation as well as industrial uses of lac and shellac. Predators and parasites of the lac insect are also receiving attention. Glover, Gupta, Misra and Negi have done valuable work. Work has also been done in some other parts of India.

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[1] Information kindly supplied by Carpenter and Anand Rao (Entomologist).

## Forest Entomology.[1]

Simultaneously with the development of Agricultural Entomology, the insects attacking forest trees were receiving attention, and there are numerous references to forest insects in the Indian Museum Notes. In 1898 E. P. Stebbing published a booklet on Forest Insects. He was appointed Imperial Forest Entomologist in 1900, and when the Imperial Forest Research Institute was established at Dehra Dun in 1906, Stebbing was appointed Forest Zoologist. He was able to make an extensive survey of Forest Insects, chiefly of the Insect Fauna of *Shorea robusta* and the conifers. In 1909 he left India. In 1914 appeared his excellent book on 'Indian Forest Insects'.

Imms was appointed Forest Zoologist in 1911 and, within his short term of office of 16 months, he did valuable research work and laid the foundation of an authentically identified insect collection, a good library, and an adequate laboratory equipment, the three essential requirements for research. C. F. C. Beeson was appointed Forest Zoologist in 1913 (the designation of this post was later changed to Forest Entomologist). During Beeson's term forest entomology made good progress. and a systematist was added to the staff. M. Cameron was appointed Systematic Entomologist in 1920 and was succeeded in 1923 by J. C. M. Gardner. Many insect pests of Forest trees have been studied and control measures devised. Ecological standpoint has received particular attention. *Hoplocerambyx spinicornis* Newm. the heartwood borer of *Shorea robusta* has been controlled by an ingenious device of trap-trees felled at the time of the flight period of the beetles. Biological control of defoliators of teak, 'Shisham' (*Dalbergia sissoo*), and mulberry has been taken up as a special line of investigation. An intensive survey of the fauna of sandal tree was undertaken in connection with the Spike disease (Beeson, Chatterjee and others).

Considerable advances have been made in systematic entomology, and a reference collection of 15,657 species has been built up, and further additions are being made every year. Gardner has paid particular attention to the classification of the coleopterous larvæ, and similar work on the lepidopterous larvæ is in progress. The results of these investigations have appeared in the Indian Forest Records, of which a separate Entomological series has been started lately.

## Medical Entomology.

Medical Entomology provides the most dramatic and glorious chapter in the history of applied entomology. It is only forty years ago that insects were first incriminated as agents

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[1] Based on the information kindly supplied by Gardner.

in disseminating human and animal diseases and since then discovery has followed discovery in rapid succession, and the results of these discoveries have been of utmost importance to humanity.

India has made valuable contributions. Ronald Ross, in 1898 discovered the developmental stages of the bird-malaria in the gut of a culicine mosquito, and announced to the world his discovery that certain 'dapple-winged mosquitoes' were the carriers of malaria. Immediately a Commission to investigate the malaria problem was appointed. Daniel, one of the members of this Commission, arrived in India in December, 1898 to substantiate the findings of Ross. By 1900 the Anopheline mosquitoes as vectors of human malaria had been conclusively implicated and had already attracted the attention of Austin, Giles, James and Liston. Giles advocated the desirability of a thorough investigation on the Indian Culicidæ and invited workers to send him specimens.

Partly through the discoveries of Ross, and the group of eminent workers that followed him, and partly because of the importance of malaria to India, the largest amount of entomological work has been done on mosquitoes. Theobald had obtained, in 1900, collections of biting insects of India and described the mosquitoes in his 'Culicidæ of the World', the first volume of which was published in 1901. Stephens and Christophers, member of the Malaria Commission arrived in 1901 and started their Entomological investigations. In 1904 James and Liston wrote their classical work giving descriptions of the species of *Anopheles*. In 1905 Christophers wrote a Memoir on the Importance of Larval Characters in the Classification of Mosquitoes. The Imperial Malaria Conference, at its first meeting, held in 1909 recommended the creation of a Central Scientific Committee to carry out routine work on the distribution and bionomics of the different species of *Anopheles*. In 1910 the Central Malaria Bureau was started and field laboratories were added to carry out research work on mosquitoes and malaria.

At this period (1911) an important step was taken which greatly helped the development of medical entomology in India, viz., the Indian Research Fund Association was organized to supervise and finance research enquiries into various human diseases and also on important entomological subjects closely connected therewith. Ever since its inception the Indian Research Fund Association has been financing, with the grants received from the Government of India, enquiries on entomological problems connected with the transmission and eradication of malaria, oriental sore, kala-azar, plague, etc. etc.

In 1913 Patton and Cragg published their comprehensive Text-book on Medical Entomology and the Indian Research Fund Association started the Indian Journal of Medical Research.

Prior to this the results of various enquiries were being published either scientific memoirs or reports of commissions, those directly connected with malaria appeared in the Paludism, a journal started for the purpose.

Work on mosquitoes continued and in 1921 a taxonomic inquiry was started under Barraud, and in 1926 Puri started investigations on the comparative anatomy of the larvæ of the Indian Anopheline mosquitoes, and made important contributions. The Ross Field Experimental Station was started at Karnal to carry out investigations on the bionomics of mosquitoes and similar work started at Delhi. In Bengal and Assam Strickland and Iyengar were making valuable contributions to the problems of the distribution and habits of the different species of *Anopheles*.

In 1933 was published Christophers' volume of the Faûna of British India on Anophelini, dealing with 43 species and a year later Barraud's volume on Megarhinini and Culicini dealing with 272 species.

Insect carriers of other diseases had not been ignored. Ross worked in Assam to establish the mode of transmission of Kala Azar. However, it was not until the opening of the King Institute of Preventive Medicine at Guindy, Madras, that any entomological work in connection with Kala Azar was taken in hand. Patton in 1904 started experiments on the transmission of Kala Azar with lice and bed-bug. From 1924–32 the Kala Azar Commission, under Christophers and Shortt, carried out investigations on the bionomics and anatomy of *Phlebotomus argentipes*, a probable vector of Kala Azar and Oriental Sore. Sinton has made valuable contributions to the taxonomic studies of the Indian species of the genus *Phelebotomus*.

In 1933 the Sandfly fever became a problem of sufficient magnitude for the Military authorities in the North-West Frontier Province, to ask for the services of an entomologist and Puri studied the bionomics and control of these insects under field conditions. Once again, a year or so after the earthquake at Quetta, there was a severe outbreak of Oriental Sore and the Indian Research Fund Association instituted an enquiry under Smith to investigate the causes of the increase in the number of Sandflies and their control.

The close connection of rat with bubonic plague was known to the Moghals. However, it was not till 1898 that Simond had succeeded in transmitting plague from a stricken rat to a healthy one, through the agency of an infected flea. In 1904 Liston working in Bombay confirmed Simond's observations and in 1905 the plague Commission was appointed. Taxonomic work on fleas was done by Jordon and Rothschild in England; Bacot carried out researches on the bionomics of these insects at the Lister Institute; transmission experiment were undertaken at Bombay by Liston, Lamb, Kundhart, and Chitre.

In 1907 Mackie had found that the Asiatic Relapsing fever was transmitted by the body louse—*Pediculus*. In 1934 Typhus attracted attention and Mehta is doing useful entomological work in connection with this disease.

Christopher's early work on the anatomy and histology of tick, Patton's work on Muscidæ and Cragg's on blood sucking insects, particularly the bed-bug are worth mentioning. In 1914 P. R. Awati, the first 'non-medical' entomologist to join the Medical Research Department, started his work on the taxonomy of the genus *Musca* and the bionomics of the house-fly. Mitter worked on Culicoides and Brunetti (1911) described a number of new species of *Simulium*. Puri took up the taxonomic study of Simulidæ.

The credit for rapid and phenomenal progress in medical entomology and the excellent taxonomic work on insects of medical importance, goes mainly to medical men, particularly of the Indian Medical Service, who applied their well trained and disciplined intellect to the problems of entomology. Of the non-medical workers, Howlett, Barraud, Awati, Prashad, Senior-White, Iyanger, Puri and Mehta have produced work of value.

At the School of Tropical Medicine, Calcutta, Strickland was appointed the first Professor of Medical Entomology in 1922. Excellent courses in entomology are given and valuable researches conducted, on all aspects of medical entomology, especially on mosquitoes.

The entomological problems are becoming more and more complicated, and a pre-requisite for their successful solution is a broad and thorough entomological training. As Howard (1925) has pointed out there is need for the study of all insects of medical importance without an eye for immediate results, so that we discover all about them and then apply our knowledge for their control.

## Veterinary Entomology.[1]

While India has made important contributions to Medical Entomology, exceedingly little work has been done on insects in relation to domestic animals.

Veterinary Entomology may be said to have taken its birth in 1893 with the fundamental discovery of Smith and Kilbourn, in America, that the tick *Boophilus annulatus* was the intermediate host of *Babesia bigemina*, the causal organism of the Taxas cattle fever. Two years later Bruce (1895), in Africa, found that the tsetse fly—*Glossina morsitans*, was responsible for the transmission of *Trypanosoma brucei*, the causal organism of Nagana. The causal organism of Surra, the foul disease

[1] Based on information kindly supplied by Sen.

of cattle, horses and camels in India, being a trypanosome—*T. evansi*, the attention of veterinary officers in this country was focussed on the discovery of its possible vector or vectors. This was the beginning of Veterinary Entomology in our country. With these researches are associated the names of Lingrad (1896), Gaiger (1911), Baldrey (1911), Cross (1921-22), Kahan Singh (1925-26) and others.

Lingrad had started collecting material for the study of Veterinary Entomology, and had obtained the collaboration of E. E. Austen of the British Museum, London, for the identification of flies. In 1907 Cecil Warburton published an account of the ticks 'Infesting Domesticated Animals in India'. In the same year Lefroy published an account of 'The Biting Flies of India'.

Howlett was appointed to study the order Diptera, including those that were parasitic on domestic animals. Isaac has contributed many papers on the *Tabanidæ*. Sen has done valuable work in veterinary entomology.

Veterinary Entomology has received much help from workers engaged on insects vectors of human diseases. It is to the researches of Christophers (1907) and Shortt (1936) that we owe our knowledge of the transmission of canine piroplasmosis (*Babesis canis* by *Rhipicephalus sanguineus*).

Howlett (1919) worked out a scheme for the creation of a separate organization to deal exclusively with the problems of Medical and Veterinary Entomology in this country. This organization was to consist of 10 officers and 46 assistants and the estimated cost was 4·5 lakhs as non-recurring and 2,80,000 as recurring expenditure. The First Meeting of the Veterinary Officers held in Lahore in 1917, considered and accepted the proposal and passed the following resolution :—

'That the meeting is in favour of the creation of a separate organization for the study of insect parasites of men and animals, the connection with the Civil Veterinary Department being on the lines suggested by Mr. Howlett.'

Nothing happened. The same question came up again before the Second Meeting of the Veterinary Officers held in 1923, and Bainbrigge Fletcher informed them that Howlett's proposals had been dropped, 'presumably on account of financial stringency'. The meeting then passed the following resolution.

'On account of the great importance of insects in the transmission of animal diseases, as causes of direct injury to live-stock in India, and the degree of specialization necessary for the proper appreciation of the various aspects of entomology, the staff of the Imperial Entomologist should be strengthened to the degree requisite for rendering assistance to investigators into the insect problems connected with animal diseases. Similarly, facilities should be rendered for the establishment of a staff attached either to the Imperial Entomologist, or to

the Zoological Survey of India for the study of ticks and mites concerned with animal diseases.'

There was no immediate response. However, in 1933, the post of Entomologist was created at the Imperial Veterinary Institute and S. Sen appointed. We may say that the first brick has been laid and edifice of Veterinary Entomology has yet to be erected.

Lately the Imperial Council of Agricultural Research have sanctioned a scheme for the investigation of Warble fly.

In so far as the Provinces are concerned the results of the enquiries made may be summarized briefly—' No work undertaken '.

## Entomology in Education.

### *Entomology in Schools and Colleges.*

Entomology has been the Cinderella of our educational system, and, so far, this important branch of human knowledge has been fairly effectively ignored in our schools and in our colleges. Save a few lessons in vernacular text-books, Indian boys and girls are taught nothing about insects. Our children do not rear caterpillars into butterflies as children do in other countries, nor are they seen with butterfly nets indulging in insect collection, which is considered by most Indian parents, a reprehensible manifestation of cruel propensities—*Jivhattia.* Thus from his very childhood an Indian boy learns to look upon insects as untouchable creatures to be abhorred and soon develops a marked entophobia. In our high schools the knowledge of insects acquired by those few—indeed very few, who take up hygiene as a subject of examination, is restricted to a few theoretical lessons about the disease carriers. In most cases this knowledge is confined to sketchy accounts and inaccurate diagrams in cheap text-books. With actual insects, living or even dead, the students make no acquaintance and in this they faithfully follow in the foot-steps of their teachers. Does it not seem strange that in courses of domestic economy for girls, a study of household pests should not be considered essential in a country where death spreading flies and mosquitoes breed freely, where weevils eat up grain, white ants damage wood and woolly bears spoil garments ? In the zoology course, at the intermediate stage the introduction to entomology is confined to an elementary account of the cockroach and perhaps the life-history of the mosquito. In our Universities the number of students taking up zoology is hardly 5 per cent. At the degree stage of zoology course a study of the mouth parts and the classification of the groups into orders of Linnaeus is considered sound education.

Some of the Indian Universities are now providing training at the M.Sc. stage to those rare beings who select Entomology as a ' special ' group. But often the teaching, equipment and

atmosphere provided for such a training leave much to be desired.

Research work in Entomology is recognized for the research degrees, and useful entomological work is being turned out by some of our Universities, and Insects are very often selected for cytological investigations. Of the students of zoology who go abroad for advanced training, a very large proportion select entomology for their special study. Valuable though a training in research is, it cannot take the place of fundamental training in entomology, which has become so vast as to merit a special treatment, and an independent status of a 'full subject'.

### *Entomological Education in Agricultural Colleges.*

Till 1919 the position of Entomology even in the Agricultural Colleges of this pre-eminently Agricultural country was so unsatisfactory that the Third Entomological Meeting held in February 1919 discussed the question and made the following recommendation :—

> 'Considering the great economic importance of insect pests to Indian Agriculture we recommend that all Agricultural Colleges should make provision for the teaching of Entomology'.

Our Agricultural Institutions had been fashioned after the pre-war British pattern and it is not surprising that in 1919 the atmosphere was so adverse to Entomology that even the devotees of this science had not the courage to take a bold stand, and diluted their above recommendation by a rider. They stated: 'the aim of teaching Entomology in Provincial Agricultural Colleges should be to give the students a sufficient knowledge of entomology to be able (1) to recognise the common pests and to know something of their life-history and the control measures applicable to each, and (2) to be in a position to report intelligently regarding the occurrence of any unusual pests'. Such a training could not possibly be termed anything but 'First aids in Agricultural Entomology'. The explanation for this attitude was that in the Agricultural Colleges the aim was to train farmers and fruit growers and not entomologists. It was evidently no concern of the entomologists as to how and where the entomological workers were to be trained ? Perhaps at that time the dominating idea was that an entomologist was born and not made. In his scheme of organisation of Entomological Research, Fletcher had not included entomological teaching at the Central Institute, and had consigned training in entomology in the Provincial Agricultural Colleges to the cares of subordinate entomological workers or to the visiting lecturers, delivering a few lectures.

Since then, thanks to the efforts of provincial entomologists, the position has greatly improved. All those Agricultural

Colleges which prepare students for the degree examinations in Agriculture give some training in Entomology, but with the exception of one or two colleges the standard of training is still very low. Only in a few Agricultural Colleges entomology has been regarded as of equal merit with botany and chemistry and is included among the 'principal' subjects. It is not often realized that knowledge which is superficial soon peals off and what does not soak through sufficiently deeply is lost immediately.

The University of the Panjab grants a degree of M.Sc. (Agric.) in Zoology-Entomology on the combined results of a written, and a practical examination and research thesis.

The number of men suitably qualified to conduct entomological investigations falls much short of the demand.

### *Entomology in Medical and Veterinary Colleges.*

Like our Agricultural Colleges our Medical and Veterinary Colleges have also been modelled after the pre-war British pattern. We, however, forget that while insects may not be of much importance in a cold country such as England, the case of India is very different. According to Mackie (1925) 'the unhealthiness of the tropics and sub-tropics is not a question of heat and humidity or such physical states, but is due almost entirely to the diseases which these conditions foster, so that if we rid India from the insect borne diseases, we shall go far to bring her mortality into line with that of temperate countries'. Insects are responsible for most of the diseases which appear in epidemic form in India among human beings and domestic animals, yet a sound knowledge of the insect-carriers of diseases, is not considered to be an essential feature in the medical and veterinary education of our country. It is true that medical entomology has a place in the curriculum of study in Institutions training men in Tropical Medicine and Hygiene. But is that enough? At present entomology has no place in veterinary education.

## IV. IMPORTANCE OF ENTOMOLOGY TO INDIA.

Sir Thomas H. Holland addressing the Royal Society of Arts (1926) on the 'Organization of Scientific Research throughout the Empire', said :—

> 'Anyone who has lived in a tropical country will be able to appreciate, as a consequence of painful personal experience, the importance as well as the magnitude of measures intended to stamp out noxious pests or to encourage friendly insects. Among the special branches of sciences of economic value to an empire with large possession within or near the tropical belt, I should regard entomology as perhaps first in importance'

Sir Mirza Ismail, Leader of the Indian Delegation at the Inter-Government Conference on Rural Hygiene, held at Bandoeng in 1937, thus expressed the condition in our motherland :—

> 'Of the formidable list of diseases with which India is afflicted, malaria is certainly the one which exerts the most adverse influence on the health and prosperity of her people. Although less dramatic in its immediate effects than the great epidemic diseases, such as, plague, cholera and small-pox, malaria is a relentless scourge which is responsible for incalculable suffering and economic loss. It has been estimated that some 100,000,000 people in India suffer yearly from malaria and that, of these, at least 1,000,000 die from its direct effects. The debility, poverty and apathy caused by this disease are factors of magnitude in retarding the national, social and economic progresss of the country.'

There is evidence to show that malaria was the cause of the decay of Greek and Roman civilizations and it is not surprising that *Anopheles* is the greatest obstacle in our progress.

According to Mackie (1925), 'The amount of disease, invalidism and death which occurs every year in India from the bites of insects is enough to stagger humanity'. He maintains that the 'enormous economic burden from the incidence of preventable disease which India has to bear is sufficient to prevent her rising to the position of importance to which her large population and great resources entitle her'. And, in India two-thirds of the preventable diseases can be attributed to insects.

In 1920 Fletcher made an estimate of the loss to India caused by the insect pests of sugarcane. 'Taking the conservative estimate of 10 per cent. of damage by insect pests (and this is most certainly not too high a percentage)' he placed the annual loss at over 330,000 tons of sugar, . . . . . . . . .'roughly an annual sum of three hundred millions of rupees worth of wealth of the country goes into stomachs of insects instead of into the pockets (if they have any pockets) of the people'.

According to the Report on the Marketing of Wheat in India (1937), the total wastage caused by wheat weevils is 'not less than about 150,000 tons, representing 1·6 per cent. of the average crop'—and on the basis of the upcountry prices of 1935–36 the loss has been estimated at about Rs.97 lakhs. This is but loss to one food grain, viz. wheat, alone. And it is certainly a very modest estimate, because Dean (1928) states that 'such damage is frequently estimated at 5% and that the total value of the losses caused by insects injurious to stored grain and milled products in the United States of America amounts to two million dollars annually'.

The loss caused by one insect—the Ox Warble Fly, to the hides produced in this country is 1·5 crores of rupees per annum. According to Fletcher (1921), at a very conservative estimate, the annual monetary loss from insect pests to domesticated animals in India exceeds Rs.3·8 crores.

According to Sir Walter Morley Fletcher (1931), at a very modest estimate, the losses caused to India by insects that attack crops, timber, and animal products cannot be less than 200 crores of rupees and a loss of over a million and a half of human lives. (These figures had been officially collected for the Imperial Entomological Conference.) However staggering this may be, it cannot be considered an overestimate. Hinds (1934) estimates an annual loss to North America from insect damage at $ 2,500,000,000, and according to Kavalev (1930) in the United States of Soviet Russia '..... the enormous damage inflicted by pests upon the agriculture of the Union is estimated at over 2,000 million roubles every year'.

According to Hinds (1934) loss from insects has increased during the last 50 years and is likely to increase in the future. Every day that passes the insect problem is becoming more and more serious. It is because every step in the progress of civilization is favourable for our insect foes. The methods we employ to produce food in ever increasing quantities, to store it more and more, to produce varieties which are superior and give higher yield but are not resistent to pests, and our modes of life help insects to multiply. Facilities of transport such as motor cars, railways, aeroplanes help in insect spread.

It has been said that 'insects have been responsible for more destruction of property and loss of life than caused by all wars, floods, earthquakes, fires and famines in human history', (Hinds, 1934). A bold statement but true. On the other side we have products of insect activity which are source of wealth. India holds monopoly of lac, and silk and honey are of equally great importance.

There cannot be any doubt whatsoever that among sciences of economic value in India, entomology must take the very first place in importance; unfortunately it occupies at present the very last.

## V. FUTURE OF ENTOMOLOGY IN INDIA.

That is the present position. Now how about the future! India has entered upon a new form of Government, with increased representation and increased responsibilities. Democracy at best is a very expensive form of administration and for all beneficient activities and developments money is essential. Retrenchments and reductions in the cost of administration are mere palliatives, they do not provide a cure. In most parts of the country the burden of taxation on land is already so high

that no further increase is possible. In fact our farmers are so heavily under debt that they are crying for immediate substantial relief. In the industrial field the competition is so keen that some form of protection or subsidy is demanded. In the circumstances we must either tap new sources of income—not an easy task, or we must stop wastage. India is paying a tribute of 200 crores of rupees to the demons '*Ṣaṭpada*'. What policy of defence should we inaugurate against this enemy which is destroying life and property on a scale far in excess of what any human foe can destroy. To reduce this enormous waste of our national wealth, is one of the most important and urgent problems which India has to face. It is for us to find a solution, but we are greatly handicapped. The insect problem has not yet received the recognition that its enormity demands. The number of those interested in entomology, amateurs, teachers, students, workers in pure entomology, agricultural, forest, medical, veterinary and industrial entomology, does not exceed 125. Thus for every 2·5 million people of India there is one person interested in insect study. At a very liberal estimate the total expenditure of all entomological activity—teaching, research and pest-control, would not exceed 15 lakhs a year. Against this, about 1932, the normal budget of the U.S.A. Bureau of Entomology alone was $25,000,000 and on 1st March, 1930, the total classified personnel of the Bureau was 515, and there were 100 field laboratories in U.S.A. and other countries. In addition to this, all States and all Universities and Agricultural Colleges employed large staff of entomologists.

### Public Awakening.

Before any progress is possible the population at large must be convinced that insects are its bitterest foes. We must have the public to appreciate the fact that it is of vital necessity that something immediate must be done to stop the inroads of insect pests. Our public must learn to appreciate the true value of the study of insect life. Our legislatures must learn to acknowledge that the insect problem is one of the problems on the proper solution of which the future of this country depends, and that applied entomology must develop if man is to gain health, peace and prosperity. It is the duty of the entomologists to educate the public and we must employ every possible method to achieve this end.

By every means possible we must greatly increase the number of workers both in pure and applied entomology. Public education will be a means to this end, and public awakening will increase the number of amateur workers, the class which has done most magnificent service to entomology in the past. Funds have to be obtained from the Legislative Assemblies and therefore

we must have the public behind us and the legislatures on our side.

### Future of Entomology in Education.

At the close of the Great War Sir Harry Johnston wrote an article in the Nineteenth Century Magazine on 'The Next War', a war against insects. In this article he rightly pleads for a wider knowledge of entomology. He boldly states that 'the whole curriculum of our schools wants overhauling and that instead of Euclid should be taught entomology or the science of insects; instead of puzzling over Algebra boys and girls should be well-grounded in elementary zoology, botany and chemistry'. In fact insect horrors so impressed him that he wanted 'all public servants of every degree and every branch of state employment' to pass an examination in entomology.

We cannot make progress unless in the words of Howard (1925) 'We uncloister our schools and colleges, not only the minds of the students but especially the minds of the teachers'. As to what should be accomplished I cannot do better than quote from Gossard (1925) who gave the following advice to the Section on Education, Extension, etc., etc., of the 10th Annual Meeting of the Pacific Coast Branch of the Association of Economic Entomologists in the United States of America :—

> 'This section should be specially devoted to the consideration of entomology as a necessary part of education or of nature study in rural schools, grammar schools, junior and senior schools; the inclusion of a well chosen entomological section in the Boy Scout Manual and in the publication of Campfire Girls; to secure better than casual notice on insect subjects in such papers as the Youth's Companion, Boy Life and in the standard magazines which contribute most largely to moulding the world's thoughts. It should endeavour to increase the use of entomological toys and games and if possible add to the entomological education of the clergy and those religious orders which participate in large degree in general education of the public . . . . . . . . .'

No better programme could be laid for this country. Ghosh (1919) brought the same question before the 3rd Entomological Meeting and argued that no rapid progress in control of pests and noxious insects was possible unless the people of the country became 'Insect minded' and, therefore, he considered it necessary that information concerning insects be made a compulsory subject for children in primary schools in India, and advocated that the readers for use in these schools should contain simple accounts of some of the insects commonly found in the Provinces concerned, and he emphasized that Entomology should figure prominently in all courses of nature study and advised the education authorities to enlist the help of entomological workers

in the preparation of suitable readers and text-books. The meeting unanimously passed several resolutions on the subject, but so far they have remained mere pious hopes. Entomology must take its rightful place in our schools.

### *Entomology in General Zoology Courses.*

The departments of zoology in the Universities in India have to reconsider the whole question, and impart such entomological education at all stages of a zoology course as the importance of this subject demands. We must bring education more and more in line with our needs. It is claimed for entomology that it provides full scope for the development of mind, and no other branch of zoology has such wide application to human affairs.

### *Entomology in Agricultural Colleges.*

Although great progress has been made in some of the Universities of India to give entomology its rightful place in the curriculum of agricultural studies, yet much remains to be done. There was a time when an agricultural entomologist could be considered competent to do his work well if he was familiar with crude morphology and general classification. But gone are the days of 'catch and kill' or 'cut and burn', and we have to aim at prevention rather than cure. Insect control of today is not an easy matter, what we once thought simple is becoming more involved. Further improvement of the status of entomology in the course of agricultural studies is greatly needed.

### *Entomology in Medical and Veterinary Colleges.*

Entomology has yet to fight its way into the curriculum of studies in our Medical and Veterinary Colleges. In a country where the so-called tropical diseases are responsible for at least two-thirds of deaths, a study of the carriers of these diseases cannot be ignored. In our country every medical institution should be a school for tropical medicine. Let us hope that the difficulty of finding time for this important branch of preventive medicine will not be insurmountable, and if it is found that the Medical curriculum is already too congested, is it not possible to make some knowledge of insect structure, bionomics and classification a qualification for admission to a Medical College ?

At a meeting of the Animal Husbandry Wing of the Board of Agriculture held in 1934, the question of entomology in Veterinary colleges was considered. The opinion was favourable, although it was pointed out that in a three years' course it will not be possible to deal with the subject very thoroughly. Let us hope that something material will result.

### *Training of Entomologists.*

The important question of the training of entomologists, as distinct from including entomology in the education of all classes of people, has been occupying the minds of teachers in all countries. The fifth Entomological Meeting held at Pusa in 1923 unanimously passed the following resolution moved by K. Kunhi Kannan :—

> 'That this meeting recommends to the Indian Universities that the subject of Entomology be taught as of equal rank with other branches of biological science in the courses of studies for the examinations of the Universities for the degrees in Science including Agriculture.'

The International Congress of Entomology, held at Zurich during 1925, discussed this question. The same question came up before the Congress of Imperial Economic Entomologist, 1925, and was further discussed in the Third Annual Meeting of the British Zoologists held in January, 1926, when Prof. Stanley Gardiner moved the following resolution :—

> 'That on account of the growing importance of Entomology fuller facilities for the teaching of Entomology should be provided by the Universities.'

Once again the Imperial Agricultural Research Conference, 1927 recommended :—

> 'In view of the fact that the progress of Agricultural Entomology is to a considerable extent dependent on the advancement of the science of Entomology in general, it is very necessary that more attention should be given in Universities to research and teaching in pure Entomology, which are at present hampered by the lack of necessary funds.'

I do not wish to dilate on this point. I will only say that there is growing need for a better, broader and sounder training in Entomology and as a basis a wider training in Biology, which is being greatly neglected. The Universities can play a very important part in the training of entomologists, by improving the status of Entomology in their zoology course for the degree examinations and in post-graduate courses.

### FUTURE OF INSECT TAXONOMY IN INDIA.

Now I come to another most important question. I would like to repeat that to be able to know precisely and definitely what insect is under investigation, and to be able to talk about it and write about it so that all others understand, is of fundamental importance in every sphere of insect study and more particularly in applied entomology. It is not every mosquito

that is the carrier of malarial parasites, nor is every fly a warble-fly. Even closely related species may have widely differing habits, and widely differing behaviour, and control operations based on imperfect knowledge of the identity of a pest may mean entire waste of enormous energy and wealth. I may perhaps illustrate this point by an example. Not very long ago the borers of sugarcane and related plants were all placed under one species, and such control measures as sowing of maize as 'trap crop', to protect sugarcane from borer attack, were advocated. It was only after a carefully taxonomic study had been made that the absolute futility of such recommendations became apparent. The borer pests of sugarcane would not feed on maize. Such instances can be multiplied indefinitely.

### *The necessity of developing Taxonomic Entomology within the Country.*

It is becoming more and more evident that taxonomy divorced from other branches of entomology cannot reach stability. Even in the case of some of our most important insect pests the past methods have led to a great deal of confusion. For instance, in practically every case the phases of the migratory locusts were named as different species. Our very serious and common pest of sugarcane in India—*Pyrilla*—described from pinned specimens was split into three species on the basis of small colour differences which have proved to be normal variations (Pruthi, 1937). Taxonomy can no longer be regarded as mere christening of dead insects pinned, staged or preserved. Untold confusion has been caused by this attitude. With the development of applied entomology the responsibilities of taxonomy have increased. Taxonomy must be unfettered from its present bondage and allowed free vision much beyond the cabinets and museums. It is very necessary that taxonomy must be broad based and we must recognize that life-history studies, ecological observations, facts of geographical and season variations all have an important bearing on insect identification. For such a complete study of insects it is necessary that taxonomy must go hand in hand with other branches of entomology, hence the necessity of developing taxonomy within the limits of a country.

Further, the difficulties of depending on an outside agency for taxonomic work are great, in spite of the fact that we have quick means of transport and communications. I shall illustrate my point by a specific instance.

About 1927 some insects were sent abroad, and their identifications were received after about a year. There were a few new species to which names had been given, with the remarks that their descriptions would be published; but these have not

been published so far. Ten years have gone by and, as we have not been able to obtain proper identification, our publication has been held up. In the meantime another difficulty has arisen. Another consignment of the same material was sent to the same agency in 1929. As the first expert had given up work on the group, this second consignment was handed over to another taxonomist and his identifications, received recently, do not agree with the previous identifications. If it had been possible to identify this material within the country, all this delay of years in the publication of important results of wide application would have been avoided.

### *Imperial Institute of Entomology and Entomology in India.*

While on the subject of the development of taxonomy, it will be an unforgiveable omission if no mention is made of the assistance given by the Imperial Institute of Entomology, London, to workers in India. The publications of the Imperial Institute, the two series of the Review of Applied Entomology and the Insect Part of the Zoological Record, rank among the most important publications of international utility. Besides, the Institute is rendering most valuable services in the identification of insect specimens. The condition of insect collections in this country being what it is, the Imperial Institute and the British Natural History Museum have, for years, to play an important part in fostering taxonomic work in India. During the two years 1934 and 1935 the Imperial Institute of Entomology identified for India (including Burma) 1,670 specimens. How hard pressed the Institute is, will be evident from the fact that the number of insects received for identification had risen from 101,093 in 1930 to 4,926,060 in 1935. With the rapidly growing interest in entomology and particularly in applied entomology, this demand is likely to increase greatly. In addition to the staff of seven expert Entomologists on the permanent establishment, the Imperial Institute has found it necessary to seek outside help and have made arrangements with 64 specialists, in different parts of the world, to identify insects. Although this organization is the largest of its kind in existence, even so, the Institute is unable to meet adequately the demands made upon it. A mild warning has been issued by the Directorate that they have now almost reached the limit of work that is possible with their present resources.

It is not only the Imperial Institute of Entomology that is working to the utmost limits of its resources, the world position in Taxonomic Entomology is still more unsatisfactory. Of late many of the entomologists in Europe and America have drawn attention to the imminent danger of a break down. The resolutions and recommendations of the third International Congress

of Entomology held at Zurich in 1925 may be taken as an index of international opinion on this question :—

> 'An enormous extension in applied entomology has recently taken place throughout the world. This has necessitated, as a first step, the exact determination of an immense number of insects. The result has been to show the utter inadequacy of the present means of undertaking such work'... 'Everywhere the systematic specialist is overburdened and his load has now become an intolerable one.'

Attention is also drawn to a very interesting and thoughtful address by Walther Horn (1928) to the fourth International Congress of Entomology, on the 'Future of Insect Taxonomy', where the position of Taxonomic Entomology in the world has been discussed.

The situation does not appear to have improved during the last 12 years and Neave in his address to the Royal Entomological Society of London (1935) laid great stress on further development of taxonomic work. He stated : 'At the present time the ever growing demand, rising from the innumerable investigations on insect pests and their insect parasites that are in progress all over the world, is quite impossible of satisfaction with the existing staff. It is, therefore, incumbent upon the Governments to spend more money in this direction (taxonomy) if they are to derive full benefits from the funds invested in solving economic problems in entomology'.

The fourth Imperial Entomological Conference held in London in September, 1935 unanimously demanded 'the utmost possible extension of the systematic work'. It was pointed out that there was 'still lamentable ignorance of such economically important group as the parasitic Hymenoptera and Diptera and the termites' (Neave, 1935).

It is time that we entomologists in India carefully considered the position in relation to foreign workers and particularly in relation to the Imperial Institute. The contribution of our country to the Imperial Institute is indeed meagre—£200 a year. It should, however, be possible for us to render effective co-operation otherwise. We must develop taxonomy in this country and some of our taxonomists should specialize in certain groups and thus reciprocate the valuable assistance which has been given to us for so long by the Imperial Institute and other workers. Further, it is necessary for establishing taxonomic entomology on a sound footing in India, that a scheme of deputing at the Imperial Institute a number of young Indian entomologists for the study of special groups, for terms of years, be vigorously advocated. This will be for the mutual gain of the Imperial Institute and Entomology in India. Similarly, students going abroad for entomological education should be encouraged to do taxonomic work on Indian insects.

*Insect Collection.*

Taking into consideration the area of our vast country and tremendous variety of insect life, and recognizing the fact that perhaps we do not know even one insect in sixty, our task is stupendous. We require an army of enthusiastic, careful collectors and investigators. The only paid staff for purely taxonomic work in Entomology in India consists of one Assistant Superintendent in the Zoological Survey of India and his small staff and one Systematic Entomologist attached to the Forest Institute, Dehra Dun. How utterly and hopelessly inadequate this staff is, needs no advocacy. Investigators on medical entomology have done excellent taxonomic work on small insect groups of medical value and some taxonomic work has also been done in Agricultural Institutions and the Universities, but the fact remains that today most of our taxonomic work is being done by experts, outside the country.

In the past in every country taxonomic entomology has been the outcome of the enthusiasm of amateurs and our country has been no exception. We owe a deep debt of gratitude to those enthusiastic workers, including clergymen, army men, medical men and others, who while engaged in their own pursuits, found time to collect insects and study them. Most of these voluntary workers have been Europeans, particularly Britishers. Among early collectors of Indian insects and taxonomists one looks in vain for an Indian name. Even today there is hardly a country-man of ours who is known to collect insects as a hobby. Time has come when we should shoulder this burden, and it is our duty to encourage amateur entomologists.

It is not every one interested in insects that becomes a keen collector. It is therefore essential to promote the habit of insect collecting from the very childhood and for this purpose we must go down to schools. Insect collections must form an important part of nature study and every teacher passing through a training institution must provide proof of his being able to encourage insect collection by personal example. It has been claimed for entomology 'that it can procure the maximum delight for the mind' and believing in this we must initiate others to the delights of entomological pursuits. Insect collection should be as interesting a hobby as stamp collecting and infinitely more useful.

According to Sharp (1919) 'This period ought in the history of Entomology to be marked as the age of collecting', and he states that 'to get together a collection of all the insects of a limited region is merely to lay one of the foundation stones of science of Entomology in that region'.

*Insect Survey.*

Geographical and ecological distribution is in itself a fascinating subject and it is of utmost importance in applied entomology

—medical, veterinary, agricultural or forest. Epidemiology is already considered a very important branch of medical science and it is being recognized as of great importance among workers in every branch of applied entomology. A complete survey, geographical and ecological, is necessary for a proper study of the epidemiology of all pests, and must be encouraged by every possible method. In addition to pest surveys, general insect surveys are necessary as these form the foundation of taxonomic work. All institutions teaching advanced entomology should organize such surveys and by every possible means such surveys should be encouraged.

### *Universities and Taxonomic Entomology.*

Our Universities can play a very important part in conducting insect surveys, in getting together large collections of insects and in developing taxonomic entomology. Every University in India where there is a Department of Zoology should undertake a thorough entomological survey at least of a group of insects or a geographical region or an ecological complex. We shall thus lay the foundation of excellent taxonomic work in all parts of our large country.

It should be recognized that taxonomic work is of fundamental importance in the training of an entomologist whatever line of work he may take up later on. Before an investigation is started, may it be in bionomics, physiology, ecology, distribution or applied entomology, we must be able to answer precisely, definitely and without a shadow of doubt the question : 'What is it ?' Let every student of entomology develop sufficient keenness and enthusiasm for taxonomic study, so that he realizes the importance of this question. Not only should all taxonomic work of merit be recognized for all University degrees obtained through research but it should be specially encouraged. To further emphasize the point I would draw your attention to the following resolutions moved by Horn-Escherich—Nuttal, at the International Congress of Entomology (1925). That :—

> 'The teaching of Systematic Entomology at Universities be adequately provided for by the establishment of chairs especially devoted thereto.'
>
> 'The meritorious systematic work should be regarded as qualifying candidates for ordinary and advanced degrees at Universities.'

### *Museums.*

Taxonomy and insect collection go hand in hand. In order to obtain quickly an accurate determination of insects, properly classified, named collections for comparison are absolutely essential. In every province and Indian State there should be an Institution or a Museum, with an adequate staff of

specialists and technical Assistants for taxonomic work. As long as this is not done taxonomic entomology must remain undeveloped. Such an Institution will serve as a repository of collections of all species in a particular area, will exchange duplicates with other similar Institutions and thus taxonomic entomology all over the country will develop. Whether these museums are independent institutions or form part of Agricultural Colleges or the Zoological School of a University is immaterial.

Further, we should develop at least one National Museum which should have as complete a collection of Indian insects as possible. India has lost almost all types of insect species so far described. Let us have the next best—carefully determined, properly labelled, authentic specimens of all our insects, so that future investigators have facilities for work. We must make a vigorous co-operative attempt to have at least in one place as large a collection of species described from India as we can.

### Other lines of Research.

I have laid special stress on taxonomy, but not because I consider it the be all and end all of entomology but because this field of study is not receiving in India, and in fact anywhere else, the attention which its magnitude and importance demand and deserve. In our country there is need for research in every branch of entomology. We must study the morphology of Indian types and place in the hand of our students books dealing with the structure of insects that exist in this country. In Entomology we should have Monographs of the type issued from Lucknow (edited by Bahl). Our studies in bionomics have been confined to few pests and a great deal remains to be done. Fletcher's studies on the life-history of Indian Microlepidoptera just indicate what is required for all the groups. Insect psychology, or to use a simpler language, studies in insect tropism or behaviour, are of utmost importance. If we can only discover what force guides the female Carpet beetle—*Anthrenus*, an open air insect to enter a house, however well screened with wire gauze, reach the deepest recesses of cupboards, creep in through narrowest chinks, and get at woollen garments, or, if we can discover what attracts the female *Anopheles* to man, we would be well on our path to a satisfactory control of most insect pests. Insect ecology holds the field today and it must play an important part in placing in our hands facts on the basis of which we could predict insect abundance and outbreaks. Enormous work is needed in this direction. Biological control of insect pests is yet in its infancy in India. We know very little about enemies of insects and their mass multiplication. We know still less about insect diseases. Insect pathology is a young science and full of promise. And finally we must not ignore the application of mathematics and statistics to our science, use of logarithmic

tables has entered the field. The demand is so great and so much work is to be done that we cannot get enough workers and enough facilities for the study of all the different aspects of insect life.

### FUTURE OF APPLIED ENTOMOLOGY.

As a result of general awakening to the applied value of entomology and improvement in the teaching of entomology, it is expected that more money and more men will be available for researches in this direction. In every branch of applied entomology there is need for great and immediate expansion. If India is to rise then her insect pests must go under. Any money spent for the study of insect pests will more than repay itself. In every province and in every Indian State more men are required for investigation on insects of agricultural, medical and veterinary importance. In every province an entomological section of the Department of Agriculture is a necessity. Every Medical Department and Veterinary Department should have fully trained men available for investigation of local problems and control of disease carriers. Our Forest Entomology needs strengthening. I wish to draw your particular attention to one danger. The line between pure entomology and applied entomology has no thickness, but very often an applied worker has to stop work of great importance, because the pay-master considers it pure science and will not see its future possibilities. This is the case all over the world, but more so in India. The consequences of such a policy are as serious for the development of science as for the intellectual development of the workers.

### ENTOMOLOGICAL LITERATURE.

It can hardly be disputed that no branch of knowledge can progress without literature. In this respect entomology in India is very badly placed. We have no literature worth the name in any of the vernaculars of our country. Without such a literature we cannot interest our people in this very important science. There is need for simple, popular books on insects in general and also on insects which do damage to our crops, our goods, our animals and injure ourselves. Since 1909 when Lefroy wrote his 'Indian Insect Life' no comprehensive book has been published on insects of India, and Lefroy's book has been out of print for years. Thus Indian students of entomology have to fall back on books dealing with insects of other countries. It will be a fit tribute to the memory of Lefroy, who did more for entomology in India than any one else, if his book is revised and brought up-to-date. There is need for scientific treatise on applied entomology with reference to the particular conditions of the country. Abundant material is available and time has come when this work should be taken in hand.

There is enormous literature scattered in numerous journals and publications dealing with Indian insects and a complete bibliography of this literature is one of the greatest needs.

The brief and incomplete outline of the history of Indian Entomology that I have placed before you must have shown that there is need for an authentic history of Entomology of this country. Books printed elsewhere ignore our country completely, we must make up this deficiency ourselves.

We must vigorously push forward the publication of the 'Fauna of British India' and Catalogues of Indian Insects.

### International position of Entomology.

Entomology has long ceased to be a subject of purely national interest and is becoming more and more a subject of great international importance. Insects recognize no political barriers nor separate governments. Today they conquer one country tomorrow another. Modern means of transport—railways, motor cars, steamships, airships, aeroplanes—have made the spread of insect pests a matter of international consideration. India has already been invaded by San Jose' Scale, American Blight, Potato Tuber Moth, and Codling Moth, to mention but a few. Further, insects such as the locusts born and bred in one country may fly over to distant lands. Nations are awakening to the international importance of insects, and Locust research and control are already in operation on international basis. Therefore, an entomologist, to whatever country he may belong, has to take an active interest in the international entomological problems. With ever increasing quarantine restrictions and legislative measures against the spread of insect pests, demands for certificates of freedom from pests, notification of outbreak of pests on international basis, India must develop her entomology so that she can take her proper and rightful place in the international assembly of entomologists. You will be interested to know that the Imperial Institute of Agriculture, Rome have announced that Radio communiques of that Institute will be transmitted for English knowing people on Thursdays.

So far we have gone on the presumption that an insect which can exist in one country can also exist in another and a pest of one country can assume the status of a pest in every country. It is true that some insects have become wide spread in a comparatively short period of time, for instance the San Jose' Scale; and yet there are others which have not been able to spread even into neighbouring territories and adjacent localities. Without a thorough study of the ecology of a species it is impossible to predict its behaviour and in the meantime much money is being spent at our quarantines in killing insects which are either already dead or which if introduced to new locality

are likely to die of their own accord. India if she is to protect herself against foreign pests efficiently then she must study the question and develop a well organized and well trained quarantine service. This important task can no longer be left in the hands of laymen.

### Entomological Journal.

For growth of entomology a periodical devoted entirely to the publication of research work in this science is essential. At present there is no such journal in India. Most of the papers on entomology, therefore, find their way into periodicals dealing with general agriculture, forestry, medicine and veterinary, or what is still distressing, into the proceedings of the various Societies and Academies and the publications of the various Universities, intermixed with subjects which are not of the remotest interest to an entomologist.

Sir John Russel mentions in his recent report that 'it is comparatively rare to find references to Indian investigations in books published outside India'. The scattered manner in which we publish the results of our researches is certainly one of the reasons for this unfortunate neglect. Sir M. Visveswaraya in his Presidential address before the Indian Science Congress of 1923, deplored the tendency to multiply our journals, which leads to defusion and disorganization, instead of co-oridnation and co-operation. He emphasized the need of one accredited journal or publication for each branch of science, which will command respect in other countries. A rough computation made reveals the fact that no less than 80 different publications in India include material on entomological subjects. Even if half of this material is of general character which should legitimately find its place in popular periodicals, the position still remains unsatisfactory. Is it possible for College and University libraries to obtain all these journals, or is it possible for any research worker to keep track of the literature in the special branch of knowledge in which he is interested? The Scientific Abstracts issued by the National Institute of Science in India and Lists of Publications on Indian Entomology published by the Imperial Council of Agricultural Research, are very incomplete because even the Zoological Survey of India and Imperial Agricultural Research Institute do not get many of the publications appearing in the country which contain valuable entomological material. Workers in medical entomology advocated the desirability of a separate entomological publication very early and in the very first meeting of the Governing Body of the Indian Research Fund Association the question of publishing an Entomological Bulletin was raised. Evidently the Entomologists being in minority lost the point and it was decided that entomological papers should be published in the Indian Journal of Medical Research. Hundreds of pages of this Journal have been devoted to first rate entomological

literature, dealing with physiology, morphology, ecology, bionomics, embryology and taxonomy, intermixed with, for instance, such subjects as Birth and Marriages among Brahmans. Thus most valuable entomological material has become out of reach of many entomological research workers. Similarly, we find excellent entomological literature in agricultural and forestry journals, buried among heap of other matter.

Almost two decades back the following resolution was passed by the Third Entomological Meeting held at Pusa (1919) :

> 'The Third Entomological Meeting is of opinion that it would be desirable to have a Journal solely devoted to Entomology and Government should undertake publication of it

The details were left to a Committee, but as most of the members proposed for this Committee declined to serve on it, the matter had to be dropped.

Lately the Forest Entomologist has at last been successful in getting a separate publication on Entomology.

It is evident that a periodical which should collect the best of all the available entomological material and publish it in a form readily accessible to all entomological workers, would be eminently desirable and would meet a real and pressing want. Such a periodical besides collecting valuable entomological material in one place, will enable workers to find out what others are engaged on, co-ordinate work, excite healthy emulation, and let the outside world know what Indian Entomologists are doing.

## Entomological Society.

So far no serious attempt has been made to have an organization to provide a common meeting ground for all those interested in insect study. The nearest approach were the Entomological Meetings arranged by Fletcher, the fifth and the last of which was held in 1923 at Pusa. It is after 15 years that we meet again in this Section.

While in the year of grace 1938 we have to consider the question of an Entomological Society for India a number of Entomological Societies have completed one hundred years of active work, and some have a still longer record of useful service.

It will not be without interest to state that the first Entomological Society to be founded was Societas Aureliana of England, established in 1745. The Societas Entomologica, which developed into the Royal Entomological Society, London came into being in 1806.

Entomological Societies were established in America in 1842, in Russia in 1861, in France 1867, in Canada 1868, in Argentine 1873. The Royal Entomological Society of Egypt was established in 1907.

It is most necessary for the future development of our science that a powerful, independent body of Scientific opinion be created to foster the growth of entomology in our country. An Entomological Society of India with branches all over the country is greatly needed.

GENTLEMEN, 'much has been done but much more remains to be done', and let us turn to our task with the full conviction that :—

> 'The entomologists are the men on whom the world must depend for much of its future prosperity', Howard (1925).

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# SECTION OF ANTHROPOLOGY

*President* :—B. S. GUHA, M.A., Ph.D., F.N.I.

# *Presidential Address*

## THE RACIAL COMPOSITION OF THE HINDUKUSH TRIBES.

The region south of the Hindukush and Karakoram mountains and lying approximately between lat. 35°–37° N. and long. 70°–76° E., occupies a strategic position in the racial geography of India, for, as seems certain, it is through the passes of the high mountain chains which guard her north-western boundaries that the northern steppe folks reached India ; and in the difficult valleys flanked by lofty spurs and drained by the tributaries of the Upper Indus we still find the remnants, if not of the main invaders, at least of those of kindred tribes who came in their wake.

The earliest references to the tribes living in this region are given by Herodotus, who speaks of 'Other Indians' as occupying the frontiers between Kaspatyros or Kashmir and the Paktyan country or Afghanistan (III, 102–105). Strabo (XV) and the elder Pliny (Natural History, XI, 36), however, specifically mention Derdai or Dardae as the name of the tribe, and refer to Megasthenes as their authority. The latter must have had in his mind the Sanskrit name 'Darada' mentioned in the Puranas and the Epics in a generic sense for the people of the N.-W. Himalayan region, who were warlike and among whom the Buddha had sent his missionaries.

In modern times the earliest mention of these tribes was by Moorcroft, who, in 1821 first drew attention to the Dards. Following him Vigne in 1835, and Cunningham in 1846, travelled through Baltistan and published some accounts of the tribes living there. In 1847, Young and Agnew crossed the Indus at Bunji and reached Gilgit. Unfortunately the report of these two intrepid officers was lost, owing probably to the murder of the latter soon after their return to Mooltan.

Detailed accounts of these tribes were given twenty years later by Leitner who succeeded in penetrating the Hunza-Nagir valleys in 1866. A large mass of information on the languages spoken in that area was brought back by him, and he was the first to point out the Aryan affinities of the Dardic language. Leitner also published anthropometric measurements of 12 men, one of whom, Jamshed, who belonged to the Kati tribe of the

Red Kaffirs was taken to England and measured by Dr. Beddoe. Drew, who for many years served under the Maharaja of Kashmir as a geologist and finally became the Governor of Ladakh, had an intimate acquaintance with the entire territory from Jammu to Gilgit and greatly added to our knowledge of the tribes inhabiting these regions by the valuable notes contained in his work on *Jammu and Cashmere territories* published in 1875. After Drew, the most important account on these tribes was by Biddulph, who was a member of the Forsyth Mission to Kashgar in 1873 and was stationed as Political Agent at Gilgit for several years. Like his predecessors however, his experience was mainly confined to the Burish and Dardic countries, and he had no first-hand acquaintance with Kaffiristan. The account given by him of the Siah-Posh tribes were derived from Kaffirs whom he met at Chitral, and other visitors to their country. Similarly Bellew's note on the Katis contained in his *Races of Afghanistan* (1880) was not derived from a visit to Kaffiristan, but was based on sources available at Kabul. The first European to enter Kaffiristan was Lockhart who entered the upper part of the Bashgul valley in 1885-86. It is to Robertson, however, who spent nearly a year (1889-90) in Kamdesh and other parts of Kaffiristan, that we owe all our hitherto available information regarding the habits and customs of the Red Kaffirs, specially the famous Kam tribe.

Systematic anthropological investigations in the North-western Himalayan regions commenced with Baron Mezö-Kovesd Ujfalvy's visit in 1881 under the auspices of the Société d' Anthropologie de Paris, in continuation of his earlier researches in the Pamirs and Russian Turkistan. Ujfalvy spent several months in Ladakh, Balti and Dardistans and published anthropometric measurements on their inhabitants. After him the next important work was that of Stein, who in the course of his three Archæological Expeditions to Central Asia during 1900–1928 measured a large number of tribes including Red Kaffirs, Khos and Hunza Burushos. In 1912, Dixon travelled through the Astor valley to Hunza-Nagir States on his way to Western Tibet and took measurements on a large number of the Burusho. In the following year, the Italian Expedition to the Karakoram ranges under de Filipi made a detailed survey of the somatic characters of six major racial groups of the Upper Indus valleys. Lastly in 1929, the author, as a member of the Scientific Expedition of the Government of India, which was sent to collaborate with Morgenstierne's linguistic survey of the Hindukush regions on behalf of the Norwegian Institute for Comparative Research in Human Culture, visited Chitral, and the Rambur and Bumboret valleys of Chitral Kaffiristan and carried out an extensive anthropological survey of the races living there.

Linguistically, the tribes living in this area have been classified under two heads, namely, Dardic and Burushaski, with

Kaffiri occupying an intermediate position between Iranian and Indian. Burushaski is spoken in Yasin and the Hunza-Nagir valleys, and as yet unaffiliated to languages of any known family, though attempts have recently been made by Bleichsteiner (*The Burushaski Language* by D. L. R. Lorimer, **1**, Preface, 1935, Oslo) to connect it with Caucasian languages. The Dardic group comprises Kashmiri, Shina, Kohistani, Khowar and Kalash ; and in Kaffiri are included Kati, Waigeli, Ashkun and Presun. Grierson is inclined to regard the Dardic languages as 'semi-Iranian' forming a link between the Iranian and Indian languages spoken on both sides of the Hindukush (*Linguistic Survey of India*, **1**, pt. 1, 108, 1927, Calcutta). The researches of Morgenstierne, however, have shown the essentially Indian character of Dardic languages, though, as is natural, in the isolation of the Hindukush region some of the common features of the Ancient Iranian and Indian languages have been preserved which are now lost on the Indian side. Neither is Kaffiri an exception, and though standing somewhat apart, it shows much closer affinities to Indian than Iranian languages, in morphology, phonetics and vocabulary, specially with neighbouring Kalash and Khowar; the last two forming a sort of connecting bridge between Kaffiri and the purely Indian languages (*Reports of Linguistic Missions to Afghanistan and North-western India*, 1926 and 1932, Oslo).

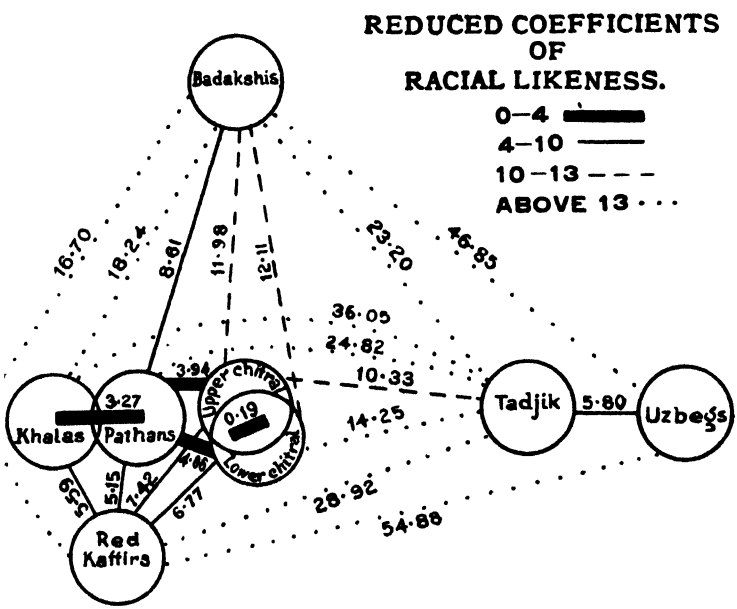



Fig. 1.

It will be well to keep this in mind in considering the racial characters of these tribes and treat the Western Group at first separately from the more Eastern one of the Upper Indus valleys. In Text-Fig. 1, I have reproduced the values of the Coefficient of Racial Likeness between these tribes. I am aware that Prof. R. Fisher (*Journ. Roy. Anthr. Inst.*, **66**, 57–63, 1936) has shown that the C.R.L. is not a measure of racial difference but a test of significance, and an unsatisfactory one at that. Nevertheless we may begin our discussion with these values without claiming anything more for them, than, that if they be not fortuitous due to the defects inherent in the method, they would give some indication as to the probability of their being random samples of the same population, *i.e.*, at their best they may be expected to tell us something of the probable alignments of these tribes.

According to these C.R.L. values therefore, there is a probability of the four Dardic tribes being random samples of the same population, but in the case of the Red Kaffirs the chances are somewhat less. With the extra-Indian groups, whether Iranian or Turkic, the chances are very little either with regard to the Dardic or the Kaffir, of belonging to the same population. Leaving them therefore aside, the results may be considered to accord on the whole with linguistic divisions, and *prima facie* there is nothing improbable about them. But beyond this chance membership of a common body we are told nothing about the racial character of that body—whether the somatic type is the same, or if there be more than one type, whether their distribution is uniform in the groups composing that body. For this, as well as for seeing how far the results obtained by the method of C.R.L. can receive independent corroborations we have to turn to the actual measurements and somatic observations for enlightenment. These may briefly be classed under four main heads, namely, stature, forms of the head and face, and pigmentation.

To take stature first, the differences between the mean values of the Kalash, Kho, Pathan and the Kashmiri are not significant, but the Kaffir appear to show significant differences from those of the first two, which may not be due to the errors of random sampling. If we examine closer, it is found that in the Kalash and the Kho the majority of the people vary from a short to medium stature, only 8 and 16 p.c. respectively in these two groups have a stature of over 1,700 mm., *i.e.*, tall. In the case of the Pathan of Dir Kohistan while the percentage of short people is about the same, that of the tall people increases to 22. Among the Red Kaffir, on the other hand, the percentage of short people is only 11 but that of the tall people is 28, *i.e.*, they have a much larger number of taller people among them. This becomes clearer when the Text-Fig. 2, showing the distribution of stature among these tribes is examined. Among the

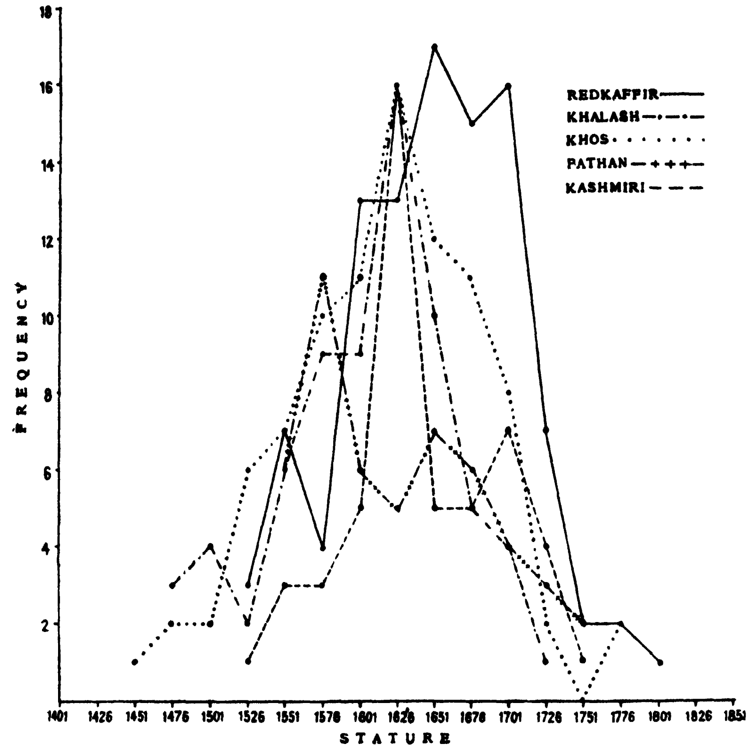



FIG. 2.

Red Kaffir, it would appear that the main range of variation is between 1,650–1,750 mm., while among the Kalash, Kho and Kashmiri it is only between 1,600–1,650 mm. The Pathans possess a predominantly short group, but they have, like the Kashmiri also a smaller number who are inclined to be tall. In other words the common factor among all these tribes is a short to medium statured people which is the dominant element among the Dardic tribes, but among the Kaffirs the tendency of the majority is towards tallness which is shared to a smaller extent by the Pathans of Dir Kohistan and the Kashmiris.

It is noticed (Text-Fig. 3) that in cephalic index the main body of the Kalash falls between 71–75, and among the Red Kaffir, Pathan and Kashmiri it is between 72–76, showing that though the Kalash have a relatively narrower head, all the four tribes are essentially dolichocephalic. On the other hand the Kho stand somewhat apart, and the distribution of the major type among them is between 76–80. There is also a small but perceptible number among them who are markedly brachy-

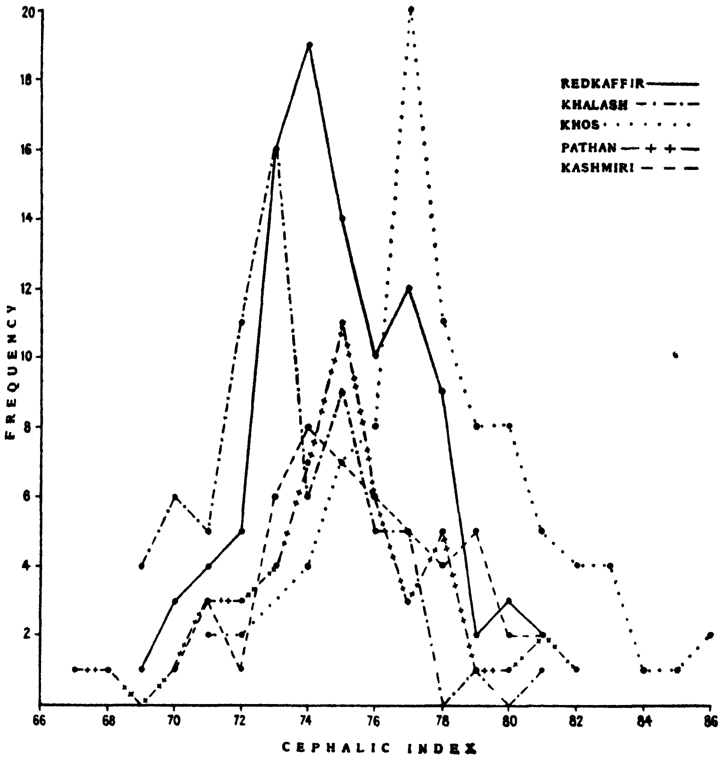



FIG. 3.

cephalic. It would appear, therefore, that the greatest common factor among all the groups is dolichocephaly, but the brachycephalic strain which has entered deeply in the Kho is present only to a small extent among the other four.

Turning to the shape of the face, the morphological height in all the groups is over 120 mm., but both the cheek bones and the lower jaw are moderately broad producing in many a pear and even a squarish type of face. In the majority, however, the facial form is longish and persons with a round face are very small. The difference in the shape of the face is not marked, though on the whole perhaps the Kalash and the Pathan possess a slightly longer face.

In Text-Fig. 4, is shown the distribution of the nasal index from which it will appear that the dominant elements in all the tribes lie between 60–70, with a small but an appreciable number of very narrow-nosed people specially among the Red Kaffir and the Kho.

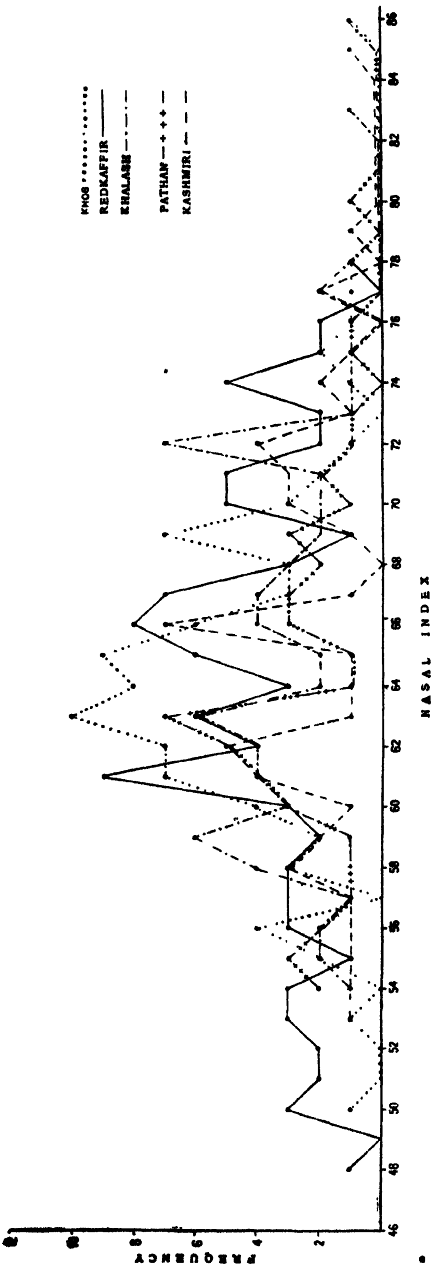

KHOS
REDKAFFIR
KHALASH
PATHAN
KASHMIRI
NASAL INDEX
FREQUENCY

FIG. 4.

There is also a fair number of people who discloses a mesorrhine index, but if the distribution curves be examined it will appear that the majority of these fall within 75, and may not be outside the range of the normal variations of the tribes. The number beyond this figure may perhaps with greater justification be regarded as due to a broader-nosed strain, more specially as among some of them the depression of the nasal root, and a rather broad flat nasal bridge were observed.

It is interesting to note that in all the four tribes by far the larger number of persons possesses a straight nose. The emphasis laid on hooked nose by Leitner, Biddulph, Ujfalvy and other previous writers, as a characteristic trait of the physiognomy of the people of this region has created the impression as if the prevailing type was so. The observations recorded by me, however, show that the percentage of men with the tip of nose slightly turned down does not exceed 27, and that of the truly hooked nose is not more than 16, in any of the tribe. If the two are combined, then the respective figures for the straight and convex noses would be as follows :—

| | Pathan. | Red Kaffir. | Kalash. | Kho. |
|---|---|---|---|---|
| Straight nose .. | 62 | 72 | 70 | 79 |
| Convex nose .. | 38 | 28 | 30 | 21 |

The dominant form among all the four groups would therefore appear to be a straight-nosed leptorrhiny. There is, however, a strain of aquiline-nosed people among both the Pathan and the Kaffir tribes which is slightly less marked among the Khos of the Chitral valley.

There is another character which requires some consideration, namely the form and shape of the eye. While there is no doubt that the vast majority among all the four groups have horizontal and open round eyes, there is a small percentage whose eyes are slanting and show distinct traces of the epicanthic fold. The figures for the four tribes are shown in the following table :—

*Form of the Eye.*

| Tribe. | Round and horizontal. | Slanting. | Epicanthic fold. |
|---|---|---|---|
| Pathan .. .. | 90 | 10 | 8 |
| Red Kaffir .. .. | 96 | 4 | 3 |
| Kalash .. .. | 93 | 7 | 6 |
| Kho .. .. | 86 | 14 | 8 |

It is interesting that a small proportion of people also show either complete absence or very slight development of hair on

the lips and face. The Kalash disclose 8% of such people, the Kho 6%, the Red Kaffir 3% and the Pathan 2%.

Taking all these factors into consideration therefore, we may regard that among the Western group of tribes living in the valleys of the Hindukush mountains a small (1) Mongoloid strain is unmistakable. It is most noticeable among the Khos and is least marked in the Red Kaffirs. Flat, broad nose and short head, whose traces are present throughout in varying proportions, I attribute to this strain. It may also be one of the contributory factors to the lowering of the general stature of the population. The presence of a large proportion of short people must, however, be attributed to (2) another strain which seems to underlie the entire Himalayan population and was probably the primitive element, references to whose occupation of these valleys occur in the traditions of most of the present tribes. I agree with Prof. Fleure that this is a variant of what Eugen Fischer calls the Oriental type characterized by a long head and an aquiline nose. In addition, (3) it is clear that a tall long-headed strain with straight nose, and (4) another with medium stature, short head and a nose long but also inclined to be straight, must be distinguished. The latter is the Pamiric race of Ujfalvy and is undoubtedly a branch of what is commonly known as the Dinaric race of Eastern Europe. Frhr. von Eickstedt is undoubtedly right in thinking that this race forms the dominant element among the Khos of the Chitral Valley (*Man in India*, **6**, pp. 244-45, 1926).

The common elements underlying all the four tribes as disclosed by the values of the C.R.L., I attribute primarily as due to the second and third racial strains. The comparatively less close association of the Red Kaffirs with the other three groups appears to be due to the predominance of the tall long-headed strain among them which is not quite so marked in the latter. To this extent I think the values of the C.R.L. may be accepted as showing the correct alignment of these tribes, and not fortuitous.

### *Pigmentation.*

Differences in the skin colour of the Hindukush tribes from those inhabiting the plains of India and the presence even of blond individuals among them, have been reported by travellers who visited these difficult valleys. Leitner, who published the measurements of two Red Kaffirs belonging to the Kati tribe, noted the ruddy skin colour and hazel eyes of the one and the reddish brown hair and hazel-grey eyes of the other (*Dardistan in 1866 and 1893*, App. 5, pp. 1–6). Similarly, Biddulph remarked (*op. cit.*, p. 128) that the complexion of the Siah Posh tribes, specially the Red Kaffirs of the Hindukush slopes, were very fair. Ujfalvy (*Les Aryens de l'Hindoukouch*, 1896) also

spoke of blonds among the Khos of Chitral. Robertson, who had an intimate knowledge of Kaffiristan, observed light eyes and fair hair among Presun children, and considered that about 1% among the Red Kaffirs had red hair (*op. cit.*, p. 170). He was of the opinion however, that as a general rule the Kaffirs were less fair than the upper classes of Chitral (*op. cit.*, p. 169).

Systematic observations on the skin, eye and hair colours of these tribes were first taken by Stein (*Serindia 3, pp. 1387-88, 1921*), who followed the instructions given in the *Notes and Queries on Anthropology*, but did not have any recognized chromatic scale to compare with. The records of his observations are given below :—

*Skin colour.*

| Tribes. | Brown. | Yellowish brown. | Rosy white. |
|---|---|---|---|
| Kaffir .. .. | 22 | nil | 78 |
| Khos of Chitral .. .. | nil. | nil. | 100 |
| Khos of Mastuj .. .. | 4 | 4 (?) | 93 |

*Hair colour.*

| Tribes. | Black. | Dark brown. | Fair and medium. |
|---|---|---|---|
| Kaffir . | 17 | 56 | 28 |
| Khos of Chitral .. .. | 5 | 91 | 5 (?) |
| Khos of Mastuj .. .. | 14 | 82 | 4 |

*Eye colour.*

| Tribes. | Dark (All shades of black and brown). | Medium (Hazel and green). | Light (All shades of blue and grey). |
|---|---|---|---|
| Kaffir .. .. | 11 | 61 | 28 |
| Khos of Chitral .. .. | .. | 91 | 9 |
| Khos of Mastuj .. | 14 | 79 | 7 |

According to these figures, therefore, the majority of people among all these tribes have a rosy-white skin colour, dark-brown hair and hazel or green eyes. There are in addition a

distinctly blond element with blue and grey-blue eyes and medium to fair hair, and a dark one with brown complexion, black eyes and black hair. Among the Kaffirs both these two strains are well marked, but the Khos appear to be overwhelmingly of rosy-white skin colour, medium eyes and dark-brown hair.

The observations recorded by me on integumentary colours were obtained with the help of the standard scales of von Luschan, Martin and Fischer. As is well known, these scales are neither comprehensive nor quite satisfactory, specially the chromatic scale of von Luschan. Greatest care, however, was taken in matching the different shades in good daylight, and though some of them were approximations and not of exact correspondence, they have an advantage over visual impressions unchecked by any objective standard.

The results of these observations are summarized in the following tables :—

*Skin colour.*

| Tribe. | Dark brown. | Brown. | Light brown. | Rosy white. | Sallow white. |
|---|---|---|---|---|---|
| Pathan . | .. | 14 | 16 | 70 | .. |
| Kalash .. . | .. | 6 | 10 | 74 | 10 |
| Kho . | .. | 5 | .. | 93 | 3 |
| Red Kaffir .. | 2 | 19 | 11 | 63 | 5 |

*Eye colour.*

| Tribe. | Black. | Dark brown. | Light brown. | Hazel and green. | Grey-blue and blue. |
|---|---|---|---|---|---|
| Pathan . | 18 | 44 | 18 | 8 | 12 |
| Kalash .. .. | 6 | 26 | 29 | 24 | 15 |
| Kho . .. | 2 | 29 | 38 | 20 | 11 |
| Red Kaffir .. | 5 | 28 | 33 | 22 | 12 |

*Hair colour.*

| Tribe. | Black. | Dark brown. | Light brown. | Fair. | Red. |
|---|---|---|---|---|---|
| Pathan .. .. | 49 | 37 | 11 | .. | .. |
| Kalash .. .. | 53 | 17 | 12 | .. | .. |
| Kho .. .. | 23 | 43 | 32 | 2 | 1 |
| Red Kaffir .. | 51 | 7 | 11 | 18 | 1 |

Among the Red Kaffirs 12%, among the Kalash 18%, and among the Pathans 3% had grey hair.

It will be seen that while the above figures are in general agreement with the results obtained from Stein's observations regarding the occurrence of a dark, medium and a blond element among these people, the presence of a light-brown strain seems to have escaped his notice. The respective proportions between the various elements require also some modifications, specially his intermediate group of medium-eyed people for which he gives a very high percentage. It is possible that the light-brown and the hazel and greenish eyes were classed together in his medium group, and a sufficient distinction was not made between the light-brown and the truly blond hair. It should also be remembered that Stein's records were made on very small samples, namely 18 Kaffirs, 22 Khos of Chitral and 28 Khos of Mastuj against 100 Red Kaffirs, 90 Khos from Chitral and 150 Khos from Mastuj and upper Chitral observed by me. Percentages based on such small numbers, which can on no account be regarded as representative samples of the populations, are apt to be misleading and must always be taken with reserve.

If now these observations on integumentary colours are considered in the light of the metric data discussed above we may regard the brown strain as due to the Oriental race which seems to be at the basis of the population of the entire region. We have found this element to be strongest among the Pathans where also the darker strain predominates. To the Mongoloid race may probably have to be attributed the light yellowish brown tint in the skin colour and in part also to black hair and dark-brown colour of the iris found in many individuals. The lighter skin, eye, and hair colours appear unmistakably to be due to the rest of the two strains. As the truly blond with sallow white skin, grey-blue eyes and fair hair is comparatively more marked among the two Kaffir tribes, where also the tall long-headed element is conspicuous, the conclusion seems unavoidable that blondness is more associated with this race. A rosy-white skin colour with light-brown hair and medium eyes appears to be the characteristic of the Dinaric type which is dominant among the Khos of the Chitral valleys.

To turn to the Eastern group, the Burusho live in the extremely difficult rugged valleys formed by the western ranges of the Karakoram mountains, north of Gilgit, between Latitude N. 36°–37° 10′ and Longitude E. 74° 10′–75° 40′, in the States of Hunza, Nagir and Yasin, in the last of which a variant form of Burushaski known as the Werchikwar is spoken. The total number of the Burusho of the Hunza and Nagir valleys as recorded in the Census of 1931 is 20,813, and of the Werchikwar-speaking Yasineso 7,518, making a grand total of 28,331 persons (Lorimer, *op. cit.*, **1**, pp. 38–47).

Further south-east in the Upper Indus valleys live the Baltis, the Brokpas (the highlander section of the Baltis), the Machnopa and the Purigi. Of these the first and the last are now Tibetanized in speech, but the Brokpas and the Machnopas still retain their Dardic languages.

Leitner (*op. cit.*, App. 5, pp. 1–7) was the first to publish measurements on the Burusho of which one was from the Hunza and five from the Nagir valleys. The Hunzukut was a dolicho and the others were mesocephals. They were of medium stature excepting Khudayar who was very tall (182 cm.) and had light eyes. The nose was usually straight, but two had slightly aquiline noses. Dixon, who visited the Burushaski country in 1912, measured a series of 92 Burusho of the Hunza valley. Morant has recently published (*Journ. Roy. Anth. Inst.*, 66, 1936) statistical analysis of the measurements taken by Sir Aurel Stein on 95 men from the Hunza valley, but unfortunately the value of his constants has been marred by his inclusion of 20 Wakhis in his sample who penetrated in the Herber valley in recent years.

The measurements taken by Dainelli comprise 150 Baltis, 50 Brokpas, 50 Machnopas and 50 Purigis. In Text-Fig. 5 the

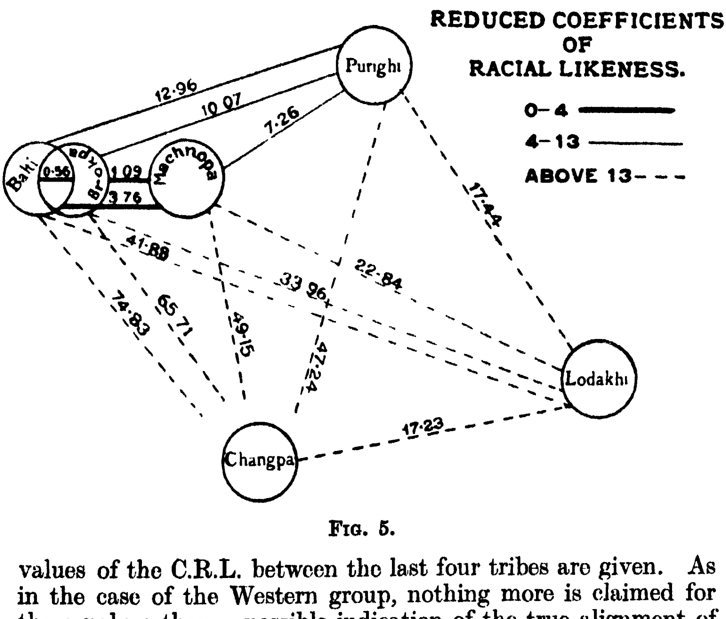



**Fig. 5.**

values of the C.R.L. between the last four tribes are given. As in the case of the Western group, nothing more is claimed for these values than a possible indication of the true alignment of these tribes. If the figures shown be not fortuitous due to the inherent defects of the method, there is a probability of the first three constituting random samples of the same population.

With the Purigi, however, the chances are somewhat less. Now if the individual characters are considered se arately it would seem that so far as stature is concerned (Text-Fig. 6) the main

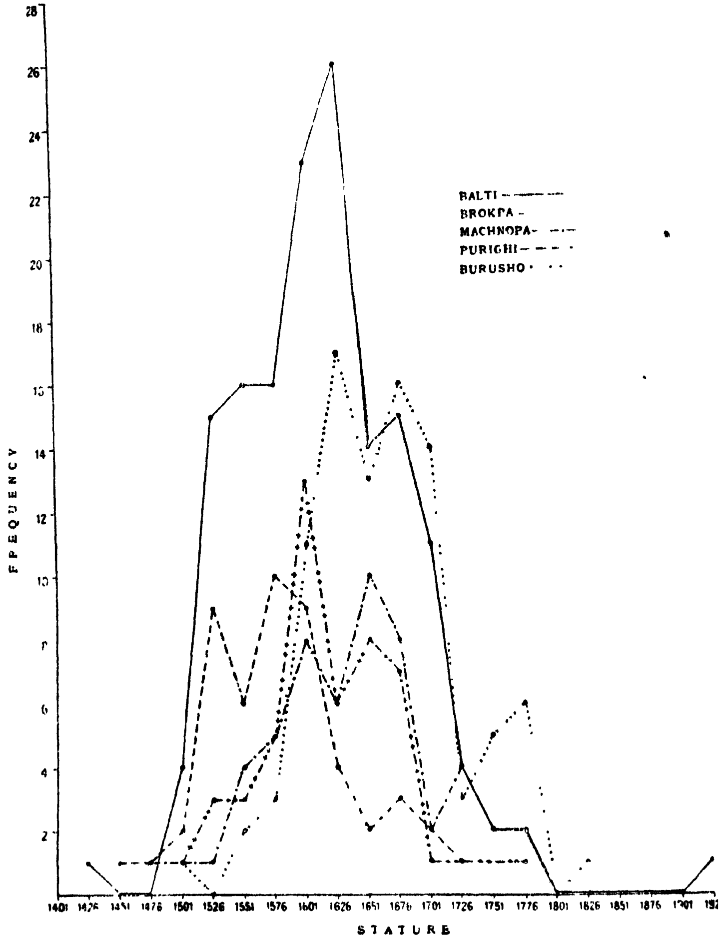



FIG. 6.

distribution of the Burusho lies between 1626–1701 mm., 35% of the people being tall. Among the Dardic group on the other hand, the main distribution lies between 1590–1690 mm. with a small proportion of the tall (the percentage not exceeding 14 in the case of the Brokpas) but a large percentage of the short.

Among the Purigi the percentage of the latter is as high as 58, in the Baltis 34, Machnopas 26 and in the Brokpas 22. In other words, the characteristic feature of the Dardic tribes, as was also noticed in the western section, is short to medium stature, the Burusho containing more of the taller element.

With regard to the head form, the mean value of the cephalic index of the 92 Burusho measured by Dixon is $77{\cdot}45 \pm {\cdot}26$ and that of the 75 measured by Stein is 79·3. Among Dixon's Burusho 35% were dolicho and only 14% brachycephalic. The main distribution, as shown in Text-Fig. 7, falls between 75–80.

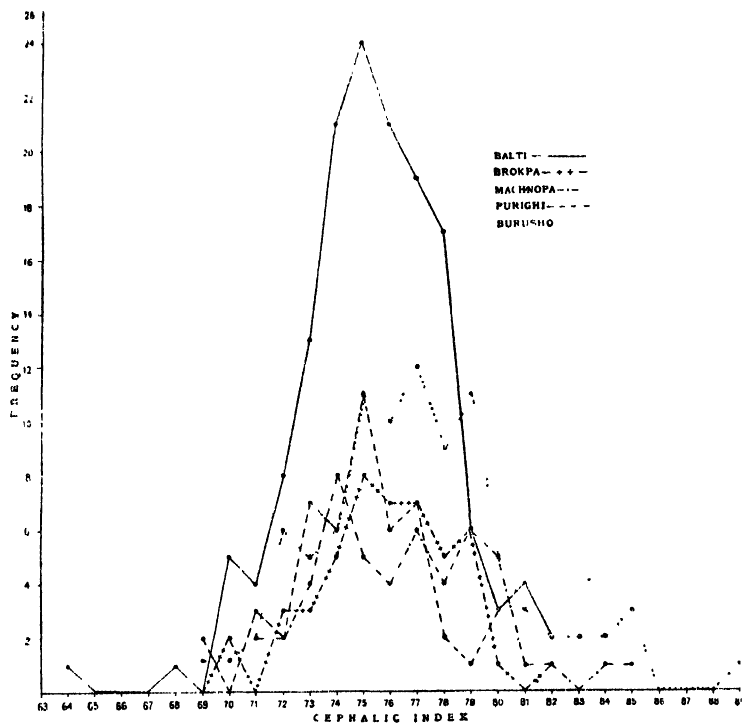



FIG. 7.

The mean cephalic index of the Baltis measured by Dainelli is 75·69, of the Brokpa 75·89, Machnopa 76·92 and Purigi 75·32. The main distribution of the Baltis falls between 74–78, that of the Brokpa 75–79, Machnopa 74–77 and Purigi 72–77. In all these tribes there is an appreciable element of hyperdolichocephals and the dominant type is dolichocephalic, the percentages being 64 for the Purigi, 52 for the Balti, 49 for the Brokpa and 42 for the Machnopa, among whom there is a small (8%) but distinctly

brachycephalic strain. Compared to the Dardic tribes therefore, the Burusho are broader headed.

In Text-Fig. 8, I have represented the distribution of the nasal index of the 5 tribes from which it will appear that two distinct types are represented. The leptorrhine type is dominant among the Baltis, Brokpas and the Machnopas, but among the Purigi and the Burusho the prevailing type of nose is broader. The percentage of the platyrrhine, however, is very small, being only 8 among the Purigi and 12 among the Burusho. On analysing the nasal form it appears that the mesorrhinic index is not due to shorter nasal length but rather to a greater breadth. Among the Baltis, Brokpas and the Machnopa the mean nasal height exceeds 52 mm. and among the Burusho and the Purigi it is 51 mm. The mean nasal breadth, however, centres round 37 mm. in all the tribes.

To turn to the shape of the face, the mean morphological height is 118·06 among the Burusho, 117 among the Balti, 118 among the Brokpa, 117 among the Machnopa and 118 among the Purigi. It is therefore, considerably shorter than in any of the tribes belonging to the Western group, where the minimum mean height is never below 121 mm. Dainelli did not measure the bizygomatic diameter, but judging from his bimalar breadth the shape of the face does not appear to be longish but rather more like that of the pear.

Materials concerning the non-metric characters of these tribes are very scanty, but from figures published by Biasutti (*Spedizione Italiana De Filippi Nell' Himalaia, Caracorume Turchestan Cinese—1913-14*, 9. *227–32*) it appears that supra-orbital ridges were marked in 78% among the Machnopa, 45% Brokpa, 40% Purigi and in only 20% Balti. In the rest they were either feeble or entirely absent. The nasal bridge is usually prominent but among 23·4% of the Balti, 12% Brokpa and 24% Purigi it tends to be flat.

The figures given for pilosity shows that in 21% of the Balti, 26% Brokpa, 18% Machnopa and 44% Purigi, facial hair is entirely absent, and among an equal proportion it is very moderate.

From all these considerations it would appear that the basic racial type is the same dolichocephalic strain with prominent long nose, which was found to be underlying the population of the Western valleys. Among the tribes of the Upper Indus valleys it is very much stronger, specially the Machnopa. There is no doubt that among the Burusho also this is the basic type. We may consider therefore, that this variant of the Oriental race is the dominant strain in the North-western Himalayas and may be regarded as the characteristic type of this region. There may also be a more primitive ancient layer of short-headed but mesorrhinic population as Biasutti thinks, but I am inclined to

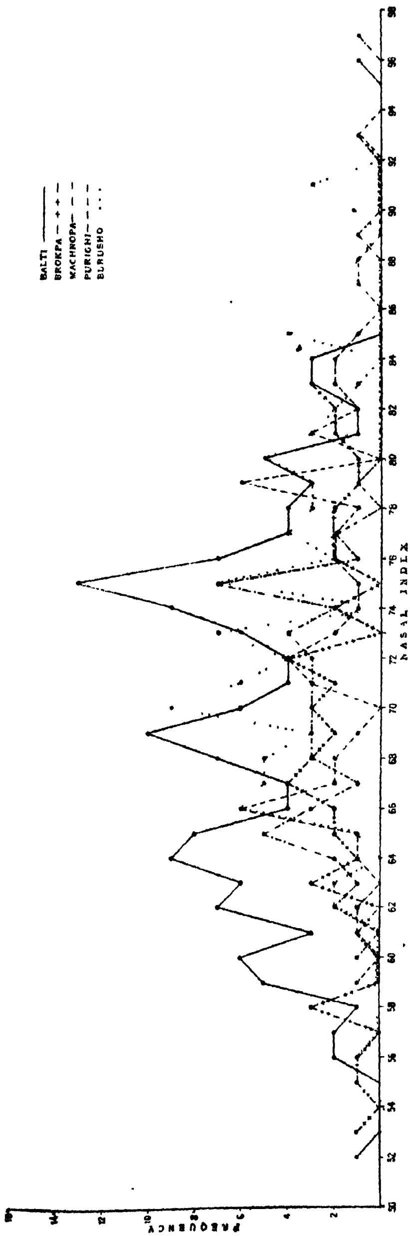

BALTI
BROKPA
MACHROPA
PURIGHI
BURUSHO
NASAL INDEX
FREQUENCY

FIG. 8.

the view that the undoubted Mongoloid strain present in these tribes is responsible for mesorrhiny. Among the Western tribes it appears very probably to be the contributory cause, and if we consider in this connection the prevailing smoothness of the forehead and the scantiness or the entire absence of facial hair in a large portion of the population, it is difficult to doubt that the Mongoloid blood has entered considerably among the population. Attention has already been drawn to the fact that the increase in the nasal index observed among many of the individuals in these tribes is due not so much to the shortness of the nasal height as to the increase in the nasal breadth, a characteristic more observed among the Mongoloid races than others, and lends further weight to the view of the Mongoloid origin of mesorrhiny seen among an appreciable percentage of these tribes. The closeness of the C.R.L. values between the Dardic tribes therefore, is to be ascribed to the Oriental element which forms the underlying substratum among these tribes, and to this extent, the probability of all four of them being random samples of the same population may justly be recognized. In addition to these types the Dinaric strain is clearly visible among the Burusho and to a lesser extent among the Dardic tribes, specially the Machnopa. Finally the presence of the tall long-headed leptorrhine strain has also to be admitted, in particular among the upper classes though not in such a dominant form as among some of the Western tribes.

### *Pigmentation.*

The skin colour in the Dardic group is in general light brown, but as Drew remarks, often light enough for the red to show through it (the *Jummo and the Kashmir Territories*, pp. 423-24, 1875). Rosy-white skin colour and hazel eyes are not infrequent and as Biasutti notes, among the Baltis and the Machnopas an appreciable percentage of people with medium eyes are observed. In one individual belonging to the latter tribe (No. 43 of the Dainelli's list) blue eyes and light chestnut hair was noticed (*op. cit.*, p. 191).

Among the Burusho the skin colour is lighter, and more like that of the Western tribes. As early as 1880, Biddulph remarked (*op. cit.*, p. 38) that the people in Hunza and Yasin had ruddy complexion and fair and even red hair was not uncommon. The presence of red-haired individuals among the Burusho was also noticed by Ujfalvy (*op. cit.*, 1896, pp. 258-59). Stein's records of the integumentary colours of the Burusho summarized by Morant (*op. cit.*, pp. 35-36) indicate that 94% of the people had rosy-white skin colour, 5% brown and only 1% yellowish tint. Among 35% of the people the colour of the eye was dark, in 50% medium and in 15% light. In 76% the hair was black but in 24% it was fair.

As in the case of the Western tribes, I would ascribe the darker element to the Oriental and the lighter medium strain to the Dinaric races. The truly fair or the blond element appears more probably to be due to the tall long-headed race as seen in the Kaffiri tribes.

From the foregoing review of the data available on the physical characters of the Hindukush tribes the basic racial strain appears to be a variant of the Oriental race described before. I was at one time inclined to accept Biasutti's suggestion of a more primitive layer of a short, long-headed mesorrhinic population, but a careful survey of the somatic traits of the Western tribes has convinced me that the cause of mesorrhiny is Mongoloid admixture. This seems also to be true in the Eastern valleys. The 'tipo-Dardo' of Biasutti and the 'Dardic type' of Ujfalvy 'with faces like birds of prey and aquiline noses' is not a separate strain but only an accentuated form of this basic type. The darker skin colour and black eye and hair are undoubtedly due to this race, though the Mongoloid strain which has certainly entered in the population may also be a contributory cause.

Besides this principal race we have in the North-western Himalayan region the southern extension of the Dinaric race. In its strongest form it is found among the Khos and the Burushos, but it occurs also among the Dardic tribes. If the records of the integumentary colours are considered it is difficult to escape from the conclusion that it is essentially a race with medium eyes and hair, but of light skin colour. The large percentage of such people among the Khos and the Burusho is largely due to this type.

It has undoubtedly spread from the Central Asiatic regions around the Taklamakan desert where its presence has been known from the earliest historical times, and among the tribes of the Pamirs it is found in its present form.

The third and the last racial strain is the tall dolichocephalic type with long but straight noses. There is no doubt that it forms a very important layer in the population of the entire region in both the Western and Eastern Dardic tribes. Its presence in the upper classes of the Burusho also is undoubted. Ariëns Kappers has shown (*An Introduction to the Anthropology of the Near East*, pp. 94–125, 1934) after a careful survey of the races of the Aral-Caspian regions that the characteristic of the Caspian or the tall, long-headed race is the clustering of the main peak around the values of 72–74 in the distribution curve of the Cephalic index. In the Kaffir tribes of the Hindukush, the Red Kaffir and the Kalash we notice the same tendency. In stature, nasal form and the shape of the face also it is similar to the Aral-Caspian type and closely related to the strain which forms the dominant element in the North European race. Distinction mainly lies in the integumentary

colours. Whereas in Sweden the blond type represents 49% of the population and the brunette only 6%, the rest being intermediate, among the Kaffirs the former does not exceed 15%. The late Prof. Dixon, whose knowledge of the racial ethnology of the world has not been surpassed, was of the opinion that 'the original skin colour of this tall, long-headed race in the steppe region of Eur-Asia was probably fair with brown hair and hazel eyes but they had inherent in them a strong tendency towards blondness, which whenever the conditions favoured became more and more pronounced reaching its climax in the Baltic regions' (*The Racial History of Man*, p. 484, 1923). We know that pigment is caused by two or more pair of genes with at least one pair of genes for what are called colour activators. A deficiency mutation will suppress the appearance of pigment producing the condition known as blondness. It is certain that in this race, and as well as at least in another, namely the East-Baltic, this deficiency mutation must have occurred at some time or other. The association of fair skin with dark hair and eyes in the Oriental race, such as the Badakshis, and of hazel eyes with dark hair, would seem to show that the three are not linked characters, but that the deficiency mutations for skin, eye and the hair occurred separately. The mutation for depigmentation of the skin colour probably occurred first, then that of the eye and lastly that of the hair. In the Baltic tribes the high rate of the deficiency mutation probably accounts for the large percentage of the blond, but in the Western Himalayas the activators were probably dominant over suppression causing the general persistence of the more pigmented people.

Whatever the explanation be, the blond type is certainly to be attributed to the tall, long-headed race which has almost entirely been eliminated in the tropical plains of India where conditions did not favour its retention, though in the general structure of the head and the body, the Kaffiri are not different from the Punjabi, and the Punjabi from the North-European as Eugen Fischer recognized long ago.

In sum, we have three distinct strains in the racial composition of the Hindukush tribes, namely a dark Oriental type forming the basis, a short-headed intermediate, and a tall, long-headed fair race constituting the apex of the population with a certain amount of Mongoloid admixture specially in the Eastern section. The proportions of the three vary in different parts; those of the last two being stronger in the Western valleys whereas the basic Oriental and the Mongoloid being more conspicuous in the Eastern territories drained by the Upper Indus.

Whole Sugarcane plant in front of a Bamboo clump.

# SECTION OF AGRICULTURE

*President* :—RAO BAHADUR T. S. VENKATRAMAN, C.I.E., B.A., F.N.I., I.A.S.

# *Presidential Address*

## HYBRIDIZATION IN AND WITH THE GENUS *SACCHARUM* (ITS SCIENTIFIC AND ECONOMIC ASPECTS)

CONTENTS.



### I. INTRODUCTION.

Artificial hybridization in the genus *Saccharum* has, in the past, been carried on mainly with the object of breeding improved types of sugarcanes for commercial use. Being generally propagated through vegetative means from cuttings the flower

and the seed of the sugarcane received but scant attention till the possibility of employing sexual reproduction for breeding improved types was discovered. Since then, however, the raising of canes from seed has been widely resorted to in all sugarcane countries where the canes flower and set seed owing to the quick and tangible results therefrom.

The observations herein recorded are based on a quarter century of rather intensive cane breeding at Coimbatore employing literally hundreds of parents belonging to at least six different species of *Saccharum* and four genera—two of them widely separated from *Saccharum* in taxonomic position and morphological characters. The work at Coimbatore represents the first attempt in the sugarcane world at improving the subtropical types of canes and the parents employed for hybridization have had to be wider than in most other countries because of special features associated with the type of cane and growth conditions of the Indian sugarcane area.

## II. The Genus *Saccharum*.

### *Taxonomic position.*

*Andropogoneæ.*—Both according to Hackel (1887) and Bentham and Hooker (1883) the genus *Saccharum* is placed in the Tribe *Andropogoneæ*. Both these classifications are based mainly on morphological characters and though it is not definitely stated so, yet the *Andropogoneæ* would appear to have been considered to occupy a less primitive position than other tribes like the *Bambuseæ*. Recent taxonomic work on the grasses of the world by Bews (1929) and Hitchock (1935), based on both morphological and ecological characters, also places the tribe *Andropogoneæ* among the more evolved forms as compared to the primitive *Bambuseæ* and *Festuceæ*.

The tribe *Andropogoneæ* is confined almost entirely to tropical and sub-tropical regions and includes a large number of plants of economic importance such as the edible and fodder *Sorghums*, the Sugarcanes, various essential oil grasses like the *Cymbopogon* and *Vetiveria*, and certain thatching grasses.

*Sacchırineæ.*—The sub-tribe *Saccharineæ* to which the genus *Saccharum* belongs is considered to be fairly primitive among the *Andropogoneæ* by Bews. Like many other genera the genus *Saccharum* has been occasionally revised, certain species being added to or taken away from it by various systematists. Dr. Jesweit (1927), for instance, took away *Saccharum arundinaceum* from the genus and placed it under *Erianthus*. At Kew, however, *Erianthus arundinaceous* still continues as *S. arundinaceum*.

*Saccharum.*—The genus *Saccharum* consists of erect perennial tall herbs with usually solid stems. The leaves vary both in

length and in width, those of certain *S. spontaneums* consisting practically of the mid ribs alone. The greatest width of lamina is found in the cultivated forms of *S. officinarum* particularly in the thick class of sugarcanes where widths of over 3½ inches are found. The inflorescences consist of large terminal panicles of racemes often showy with the rhachis articulate and fragile; those of *S. spontaneum* are generally smaller than those of the cultivated species. Fairly detailed descriptions are available of the cultivated types of *Saccharum*, but these are often based only on the vegetative characters as the cultivated cane is generally propagated from stems or cuttings and the crop is cut without any reference to its flowering.

The genus is of economic importance as it includes the cultivated types of sugarcane which vary a great deal amongst themselves both in morphological characters and in the conditions under which they grow. It supplies an agreeable and important article of food and keeps going an important world industry.

### *The Wild Saccharum—habitat and range of forms.*

There would appear to exist two different races of wild *Saccharums* both of which are confined practically to South-East Asia—India, Burma, the Islands of the Eastern Archipelago and New Guinea. Of these, the type represented by *S. robustum* was recently collected from the islands of New Guinea by Drs. Brandes and Jesweit (1928). Types of *S. spontaneum* have a much wider range being found from as far west as Central Turkestan and Afghanistan to as far east as Malenesia and the Tawaiian islands.

*S. robustum.*—The members of the *S. robustum* group have a family resemblance amongst themselves and are on the whole thicker stemmed and broader leafed than the *S. spontaneum* group. In breeding they have been found to possess a closer affinity with the 'noble' or thick class of canes. When crossed with 'noble' canes they yield hybrids of the same type; the type changes appreciably when the 'noble' canes are crossed with *S. spontaneum.*

The *S. spontaneum* group bears a close affinity to certain Indian canes, particularly *S. barberi*. The high juice qualities, however, of *S. barberi* at harvest—in contrast with the marked juice impurities associated with *S. spontaneum* and its progenies including hybrids—is perhaps indicative of a fairly wide intergeneric cross with *S. spontaneum* in the evolution of *S. barberi*. Results of intergeneric crosses to be referred to later in this paper support such a possibility; certain of the Sugarcane × Sorghum hybrids have shown very high juice qualities.

There exists a very wide range of forms in this group which differ widely in morphological, physiological and field characters

as well as in sugar contents. Members of this group occur in the wild state throughout India and are found growing wild in places that are liable both to severe drought in summer and flooding during rains. They are at home on river banks and tank beds which dry up in summer.

### *The Cultivated Saccharum (Sugarcane)—distribution and types.*

The sugarcanes in cultivation are divisible into two main groups, perhaps, originally derived from the two wild races previously mentioned, viz., *S. spontaneum* and *S. robustum.* The two types show in cultivation markedly different agricultural characteristics, the Indian indigenous canes related to *S. spontaneum* being on the whole hardier than the thick class of canes. On account of their comparative low yields and the fact that India does not figure in the sugar markets of the world—not being an exporting country—the Indian canes were but little known, till recently, in sugarcane literature.

*The Indian canes.*—Unlike most types, denoted by the term 'sugarcane' as ordinarily understood in the sugar world, the Indian canes are mostly confined to the sub-tropical areas of India. Most of them are fairly resistant to violent changes in climatic conditions and some of them to frost as well. Growing as they do in sub-tropical India they get but a comparatively short period of growth—perhaps six months—being limited in the early stages by severe summer and in the later stages by frost.

One of the countries which is fairly similar to sub-tropical India in growth conditions is South Africa where also the 'Uba' cane very similar to one group of canes grown in North India—the Pansahi group—has been widely cultivated and is now getting replaced by certain Coimbatore productions. The severe growth conditions of sub-tropical India have established types which though poor in tonnage yet possess certain valuable characters such as hardiness and disease resistance. Java was the first country to utilize one of these types—Chan or Chunnee of the United Provinces—to breed canes resistant to 'sereh'.

*'Noble' or Tropical canes.*—The other group of cultivated canes is the one on which the sugar industries of the tropical world have been built. They are generally designated by the term 'noble' and, on the whole, are thicker stemmed and broader leafed than the first group. They generally need a longer period for full growth, show their best performance under tropical conditions and respond satisfactorily to good treatment. The record sugar yields in this crop have been from this class of canes. They are, however, less hardy than the first group, less tolerant to adverse conditions and generally more liable

to diseases. In the number of types in cultivation they are larger as, till the starting of the Coimbatore work, all intensive work on sugarcanes was confined practically to this class. The discovery of the viability of sugarcane seed—almost simultaneously in Java and Barbados in 1887-88—was from this type of canes. These are generally brighter coloured than the first group and are, on the whole, softer, more juicy, and possess less fibre; as a class they possess a shallower root system.

### *Species of Saccharum—their chief characteristics.*

The genus *Saccharum* includes, beside others, six well defined species all closely related to the cultivated sugarcanes and with which they have been crossed as well. Their chief characteristics and distribution are given below :—

*Saccharum spontaneum* :—The types included in this species comprise a wide range of forms some of them inconspicuous plants with very narrow laminas to others growing to a height of 10 to 15 feet and not very dissimilar to the more primitive of the Indian canes. They are generally characterized by high fibre, markedly impure juices with very low sugar contents and ability to grow under extreme conditions including drought, water-logging, and frost. These are never cultivated for sugar. Types of this species occurring in India and the Eastern Archipelago have been studied in some detail at the Java and Coimbatore stations. The common Java type which is different from the main Coimbatore form in agricultural characters has been employed in the breeding of most of the recent popular Java canes and the mosaic resistance of some of them is attributed to this parentage. Similarly, one of the Coimbatore types enters into the parentage of all the Coimbatore seedlings found useful in cultivation.

The extent of variation in the forms of *S. spontaneum* in parts of India will be evident from the fact that a somewhat cursory collection of such types undertaken in a portion of Bihar in 1933-34 by R. Thomas yielded as many as eight distinct types differing in various morphological characters such as leaf width, stem thickness, size of plant and even depth and mode of branching of root system. In sugar contents they showed variation from 0·5 per cent. in juice to 17 per cent., the latter figure being higher than that of some of the Indian canes. The fact that such widely varying types exist in parts of India even to this day is perhaps indicative of certain of them being the primary centres (or centres of origin) for this species. The survey of *S. spontaneum* types in the country is being undertaken from Coimbatore as occasion permits, but there is little doubt that a well organized and thorough survey of such forms will yield very interesting results.

*Saccharum barberi* :—A group of canes rather similar to *S. spontaneum* in containing high fibre presence of the IV glume in the spikelets and ability to grow under comparatively unfavourable conditions has been placed in this species by Dr. Jesweit. They include a range of types not quite so wide as those included in the former species (*S. spontaneum*). The cultivation of this species for commercial sugar production is confined entirely to sub-tropical India and the species includes well known varieties like Katha and its allies in the Punjab, Chan or Chunnee and Saretha in the United Provinces and a few types of not much agricultural importance in Bihar.

Types of this species are found as far south as Madras being represented in Bombay by the variety Khalkya and in Madras by Hullu Kabbu. These canes arrow and set seed freely and possess an abundance of fertile pollen. The Chunnee used by Dr. Kobus of Java to breed 'sereh' resistant canes belongs to this species. This species and seedlings raised from them are prone to smut—a character which occasionally appears even in its hybrids. This is perhaps the most primitive of the Indian canes.

*Saccharum sinense* :—This includes a group of canes thicker and softer than *S. barberi* and does not at present possess much commercial value in India. It was partly used for chewing in sub-tropical India where it was liked for the purpose as being softer than canes of the *S. barberi* species. The canes of this species need more water, possess broader leaves than *S. barberi*, and are susceptible to both mosaic and red rot. They show distinctly higher glucose than *S. barberi*. These canes are related to the canes which were formerly cultivated in Japan and to the well known 'Uba' of Natal. In floral characteristics they resemble both *S. spontaneum* and *S. barberi* in possessing the IV glume, though there are differences in minor characters between them. They flower freely but do not develop fertile pollen.

It is possible that this species might have originated either in the Eastern parts of India or in countries further Eastwards.

*The 'Mungo' and other canes* :—Before passing to other species of *Saccharum*, mention needs to be made of certain groups of Indian canes that cannot be definitely placed in any of the above species.

Of such the most important is the 'Mungo' group of Dr. Barber which once had its representatives throughout the sub-tropical Indian belt from the Punjab in the west to as far east as Bengal. Though short in growth and of comparatively poor tonnage, it held till recently a dominant position on account of its excellent habit, high juice quality, uniformity of canes at harvest, and a general resistance to adverse conditions. These canes are typically short noded and in morphological and field characters suggest a distant resemblance to the 'Creole'

cane. The chromosome number in the Creole is 81 (somatic) and in the Mungo group 82. Dr. Bremer has suggested that the Creole which is similar to the Indian cane Puri may be a hybrid between a member of the Mungo group and *S. officinarum*. These canes are generally late maturing.

They do not generally flower even under Coimbatore conditions where, very rarely, arrows half emerged from their sheaths occur perhaps once in a decade. They are also markedly defective in the floral organs. In the possession of ciliated lodicules they are nearer to *S. spontaneum* than either *S. barberi* or *S. sinense* though in general field characters *S. barberi* is nearer to *S. spontaneum*. The floral parts show certain rather primitive characters and it is possible that further work might indicate this to have been a fairly ancient group of canes in India. Certain of the varieties in this group show an awned IV glume, one of the characteristics of the Sugarcane × Sorghum hybrids. The white sugar industry of Bihar—once almost the only such industry in India—was for a long time dependent upon this group of canes. These canes stand out as a distinct class but have not received sufficient attention because of their non-arrowing.

A second group of such canes is that represented by the 'Nargori' group of Dr. Barber. Most of these are fairly resistant to water-logging and possess a markedly erect habit with prominent swollen nodes. This group is confined practically to water-logged areas in Bihar, but is steadily losing hold on cultivation from the easy superiority of recent introductions. These varieties do not flower generally and even if they do, are defective in sexual organs. It has not, therefore, been possible to employ this group in sugarcane breeding.

There is a third group—the Sunnaballe group of Dr. Barber—the members of which are found in cultivation throughout India. These are represented by Dhaulu in the Punjab, Khadya in Bombay, Nanal in Madras and Majora and a few others in Assam. This group of canes is often liked for its satisfactory juice qualities and the erect habit of growth. These canes also do not generally flower and have, therefore, not been used in breeding. They are liable to smut and are fairly hardrinded as well.

The canes above mentioned—while perhaps allied to *S. spontaneum*, *S. barberi* and *S. sinense* in some respects—are not definitely placeable in any of the above because of certain important differences in vegetative and field characters. While it is not possible to trace their origin with much definiteness, there is every possibility that they may have originated from the above species of *Saccharum* by natural hybridization either between themselves or perhaps even with other genera. The results of certain recent hybridization at Coimbatore indicate a distinct possibility of other genera also being involved. It

is worthy of note that the above three groups do not generally flower and, even if they do, are defective in sexual organs.

*Saccharum robustum* :—This species is of recent discovery being a collection from the islands of New Guinea by Drs. Brandes and Jesweit and has not yet been fully described. It is very similar to *S. officinarum* in morphological characters and has been found useful both in Australia and in Hawaii for breeding seedlings of the thick or noble type. It resembles *S. officinarum* in the glabrousness of the main rhachis of the inflorescence and the absence of the IV glúme.

*Saccharum officinarum* :—This includes at present, at any rate, all the cultivated canes of the tropical world. This species has been exploited to the fullest extent—both by raising canes from seed and by hybridization—to secure better commercial types for cultivation. In recent years this species has been widely crossed with others, particularly *S. spontaneum*, *S. barberi*, and *S. robustum* with the result that it is not fair to place the newer commercial canes under this species.

The varieties in this species are generally confined to the tropics, are thicker than the species enumerated above and, on the whole, are more susceptible to adverse conditions, diseases and pests. The glabrousness of the main rhachis and the absence of the IV glume separates it from *S. spontaneum*, *S. barberi*, and *S. sinense* and renders it akin to *S. robustum*.

*Saccharum arundinaceum* :—This species was for a long time under *Saccharum*, but was recently placed under *Erianthus* by Dr. Jesweit on account of its distinctly shorter callous hairs (shorter than the spikelets), the absence of defined transverse marks in the leaf, and the marked felt of hairs at the base of the lamina inside and above the ligule. To this might be added another distinct character, viz., that the root eyes on the stem are generally in one single row in *S. arundinaceum* unlike the 3 to 6 rows of the other species of *Saccharum*.

This species is often grown as a hedge plant round betel leaf gardens in South India. It has practically no sugar, arrows fairly freely and has been crossed with *S. officinarum*. If it is a *Saccharum*, it is perhaps the largest form being larger than *S. robustum* under Coimbatore conditions. Unlike most cultivated species of *Saccharum* in which the canes die out each season, they have been known to live for over two years in this species.

## III. Inheritance in *Saccharum*.

### *Variation.*

One of the facts first noticed after the discovery of the viability of the sugarcane seed was the very wide range of forms resulting from the same parent even when the needed precautions are taken against cross pollination with other varieties. The explanation for such behaviour is the heterozygous nature

of the parents and the fact that most sugarcanes in cultivation are polyploids—the species *S. officinarum* being octoploid. The economic results resulting from the raising of seed canes have been so pronounced and the needs of the sugar industry so urgent and insistent that most sugarcane breeding stations have gone in largely for economic results unmindful of the scientific explanations behind the production of these types.

Nor can I visualize in the near future a time when such work will be taken up as a main item in the sugarcane stations of the world. The problems associated with the inheritance of characters in sugarcane would fit in better with the atmosphere of universities engaged in work of academic nature or as but side lines in the existing breeding stations. Such work is likely to be long in duration but there is little doubt that ultimately it will be needed to place sugarcane breeding in line with that of other crops. It may perhaps receive due attention when the economic results that now follow from cane breedig become scarce and work of the fundamental nature is indicated. The extent of variation will be apparent from the fact that a population of over 2,000 seedlings from practically selfed flowers of a striped cane at Coimbatore did not reveal any two which were even similar when examined in some detail. In spite of this wide variation, however, there is evident a kind of family resemblance in seedlings raised from the same species or even variety, indicating that characters are inherited in the sugarcanes, though their nature is veiled and modified by other factors.

## *In-breeding.*

As compared with most other crops there has been very little 'in-breeding' in the sugarcane and this for a variety of reasons. Firstly, the sugarcane plant is grown for its vegetative part which is milled for sugar production. As it is also propagated by vegetative means in ordinary cultivation the inflorescence is only an incidence of minor importance in the growing of sugarcanes. Secondly, the wide variation that is observed in seedlings from seeds of even the same inflorescence has naturally made sugarcane breeders averse to propagate their material from seed. Thirdly, in the absence of any apparent laws governing inheritance it does seem unprofitable to self each individual of such large populations as are usual in sugarcane breeding.

The opinion has been held in certain quarters that even in sugarcanes in-breeding is worth attempting either to eliminate undesirable characters or in the interests of science. At present, however, the breeding of improved types by a suitable combination of various parents is so much quicker in economical results that in-breeding is not likely to be taken up in the near future for this purpose. In fact, recently the Experiment Station

in Hawaii indulged in a somewhat unique experiment by planting in close proximity to one another different canes from all parts of the world—India, China, Australia, Java, New Guinea and the islands of the South Seas—with the deliberate intention of working into the parentage as many canes as possible. In such a medley of varieties all arrowing together there was every possibility, as it was deliberately intended, of pollen from different cane varieties settling on the same mother arrow and even on the same stigmas.

There have been certain rather interesting examples of 'in-breeding' at Coimbatore. One such was the raising of seedlings on a large scale from practically selfed arrows of canes belonging to the species *S. barberi*. It was found that none of the productions were real improvements on the parents and, barring one out of 1,800, the seedlings were inferior to the parents in growth vigour. A hybrid between the noble cane Vellai and the Coimbatore *S. spontaneum* was selfed for two generations without obtaining canes superior to the $F_1$ hybrid in field characters, but there was a distinct improvement in sugar content when the selection from each generation was made on this basis. There was a third instance of continuous in-breeding at Coimbatore and this was from a hybrid which was originally obtained through a rather complicated crossing between a Mauritius cane, an Indian indigenous cane (*S. barberi*) and *S. spontaneum*. Selfed for one generation a type was obtained which, though inferior to the original parent in vegetative vigour, proved distinctly superior to it in both early maturity and high juice quality, two characters for which the original cane was selected.

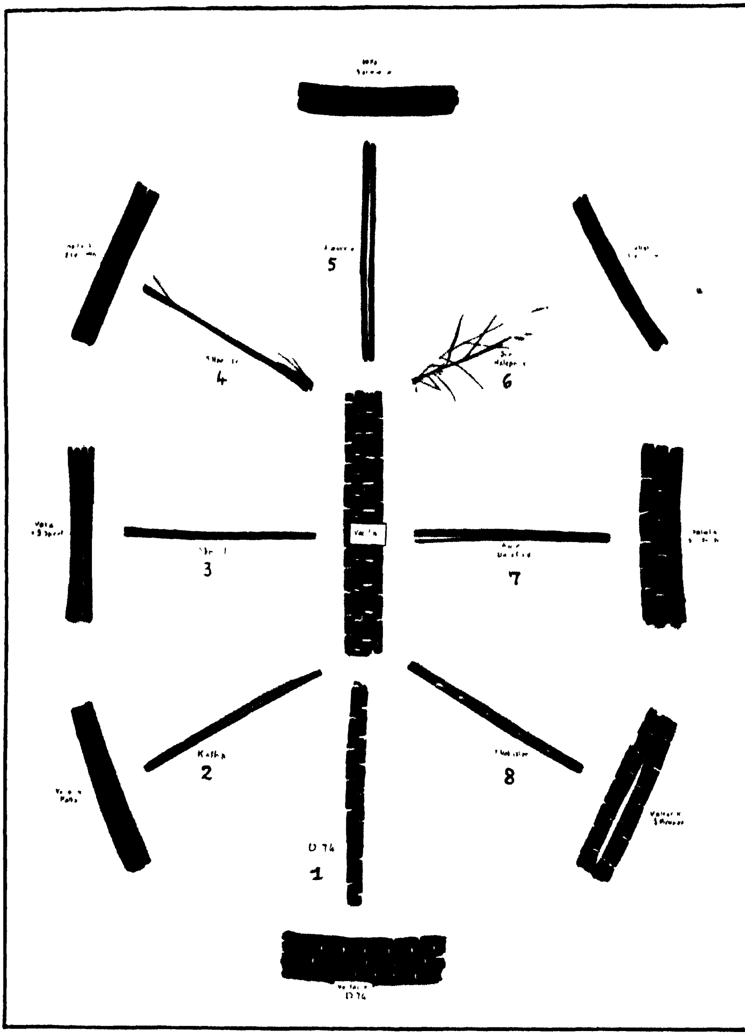
The above are indicative of the possible utilities of 'in-breeding' in the sugarcane. On Coimbatore experience its chief value is likely to be in accentuating certain characters in the new productions. The loss of vegetative vigour that is often associated with it would necessitate a futher hybridization with suitable types to improve the growth vigour.

## IV. Hybridization in *Saccharum*.

The results from 'in-breeding' proving so limited there is little wonder that most sugarcane breeding stations of the world turned their attention to hybridization between varieties, between species, and even between genera for obtaining economic results. This has rendered available for study large numbers of hybrids of fairly complicated ancestry, sometimes involving three different species of *Saccharum*.

### *Defective material.*

The available material is, however, defective in the undermentioned respects. On account of the smallness and delicacy




The genus *Saccharum* has been widely crossed resulting in different types of hybrids. It has been crossed with

(1) S. officinarum, (4) S. narenga, (7) Sorghum Durra stapf
(2) S. barberi, (5) S. arundinaceum, (8) S. robustum,
(3) S. spontaneum, (6) S. halepense, (9) Bambusa arundinacea Willd.

of the floral structures in the sugarcane and the inhibitory effect of bagging on seed setting both emasculation and selfing have been but little practised in the breeding of commercial types. As a result of this, while the mother parent is known, the pollinating parent is often not so certain as there often exists the possibility of other unintended pollen reaching the stigmas. As the propagation of sugarcanes in cultivation is through vegetative methods the breeder is often liable to fasten his whole attention on the commercially useful types with the result that generally there has been no serious attempt at a study of the whole population resulting from a combination. All the seedlings of the $F_1$ generation do not flower and, even if they do, are sometimes defective in one or the other of the sexual organs.

Though thus the material does not often lend itself to accurate conclusions, yet it is generally capable of yielding very useful indications in the matter of inheritance. While all the seedlings of an $F_1$ generation may not be from the parents employed, yet the bulk of them are.

## V. Intervarietal Hybrids.

Hybridization between different varieties belonging to the same species has been more or less confined to *S. officinarum*. The largest amount of work in this line with useful results has been from tropical countries like Java, Hawaii, Mauritius, and the West Indian islands Barbados, Porto Rico and others. Such hybridization yields seedlings of the same class as *S. officinarum* but with useful differences in the matter of field characters which render them superior to existing types.

Intervarietal hybridization in *S. barberi* was not seriously attempted because of the poor class of seedlings resulting from this group when selfed. The *S. sinense* group does not lend itself to such work because of the defective floral organs in that species. The Mungo, Sunnaballe and Nargori groups of canes either do not flower or are highly defective in the floral organs and so such work is ruled out in these canes.

A fair amount of work on intervarietal crossing in *S. spontaneum* is in progress at Coimbatore with the main object of understanding the cytogenetic composition of the genus *Saccharum*. Intervarietal crossing in the other species has not been much in vogue.

## VI. Interspecific Hybrids.

Interspecific hybridization in the genus *Saccharum* started in Java for producing disease resistant canes. Coimbatore had to take this line of hybridization practically from its inception in 1912 as it was found that breeding inside the species, be it *S.officinarum* or *S. barberi*, did not yield suitable types for the

main sugarcane belt of India situated in the Sub-tropics. It was early found at Coimbatore that even interspecific hybridization between *S. officinarum* and *S. barberi* (the indigenous canes of India) did not yield the desired result.

Faced with such a situation and the need for quick results, Coimbatore turned its attention very early to the raising of interspecific hybrids between *S. officinarum* and *S. spontaneum* (the Coimbatore form) and it is a record in sugarcane breeding that among the first forty seedlings of such hybridization (Vellai × *S. spontaneum*) a seedling of commercial value (Co. 205) should have been obtained. The success of this hybrid was a definite and clear indication of the somewhat extremely unfavourable conditions obtaining in parts of the Indian sugarcane area and there was no further hesitation at Coimbatore to utilize *S. spontaneum* in its breeding programme and the subsequent seedlings now popular in India have in their ancestry *S. spontaneum* suitably blended with both *S. officinarum* and *S. barberi*.

In interspecific hybridization with *S. spontaneum* as one of the parents—and it is generally the pollinating parent—the $F_1$ generation shows a general dominance of *S. spontaneum* characters which exhibit themselves particularly in growth vigour, hardiness, and resistance to adverse conditions. In hybrids with *S. officinarum* the *S. spontaneum* blood is often traceable in the presence of the IV glume in the spikelets. The $F_1$ generation shows obvious *S. spontaneum* field characters even when the intergeneric hybrids between *Saccharum* and *Sorghum* are crossed with *S. spontaneum*. As a parent, *S. spontaneum* introduces marked impurities in the juice and it is for this reason that such hybrids need further crossing with *S. officinarum*—what is termed 'nobilization' by the Java breeders—to ultimately secure the economic types.

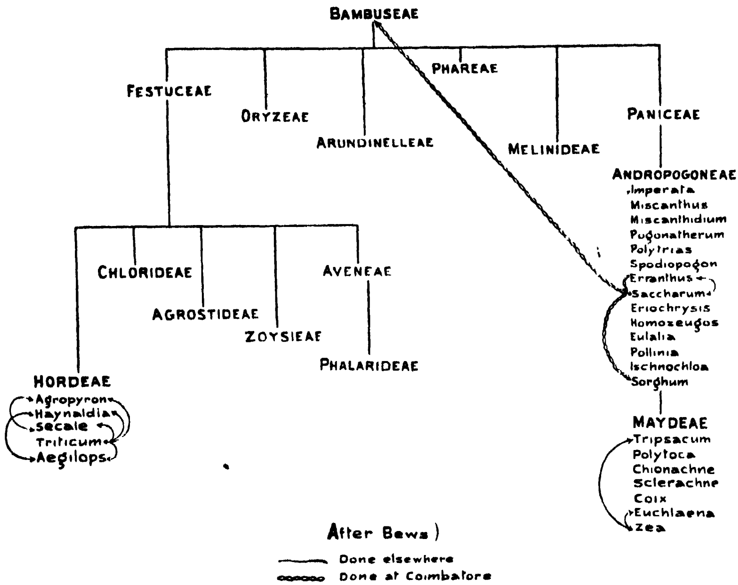
*S. robustum* has been known to introduce greater vigour of growth when crossed with *S. officinarum*. *S. arundinaceum* is a perennial as grown in South India and one hybrid raised with *S. officinarum* as mother is showing the perennial character in the hybrid.

The sugarcane world is taking more and more to such interspecific hybrids bringing into the parentage different species of wild *Saccharum* and this has been fully justified. Both Java and Coimbatore have materially benefited from the use of *S. spontaneum* and Hawaii and Australia are now using *S. robustum* for a similar purpose and for breeding hardier seedling canes for tropical regions.

## VII. Intergeneric Hybrids.

The disparity in morphological characters and distance in taxonomic position between *Saccharum* and the genera with

## INTERGENERIC HYBRIDS WITH *Saccharum*.

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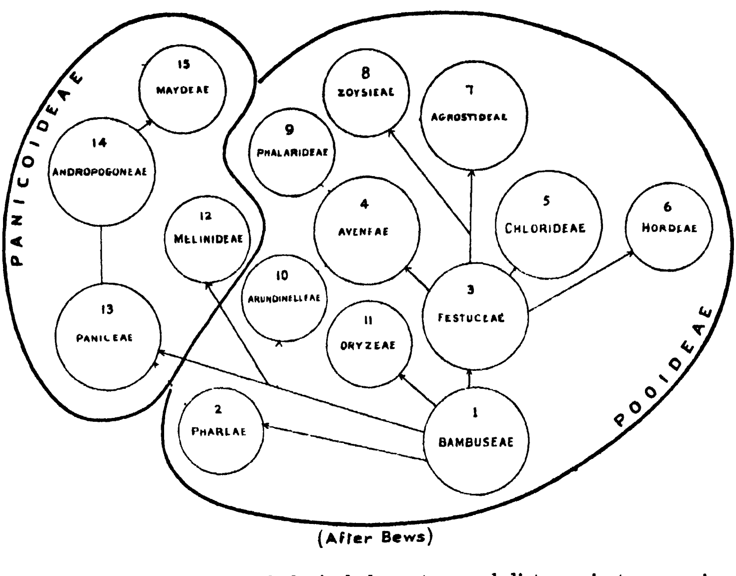



(After Bews)

The disparity in morphological characters and distance in taxonomic position between *Saccharum* and the genera with which it has been crossed is greater than in the case of the other intergeneric hybrids recorded hitherto.

which it has been crossed is greater than in the case of the other intergeneric hybrids recorded hitherto. It has been possible to cross *Saccharum* not only with other genera like Narenga (Narenga narenga), *Erianthus* (*Erianthus sara*) and *Sorghum* (*S. Durra stapf. S. halepense, S. sudanense, S. guineese*) but also with a genus belonging to a different sub-family *Bambusa*. Besides these, there are two other genera with which it would appear possible that *Saccharum* has been successfully crossed at Coimbatore. Further evidence is awaited before making definite announcements about them.

### *Hybrids with Sorghum and Bamboo.*

The two intergeneric hybrids recently produced at Coimbatore—viz. with *Sorghum* and *Bambusa*—were effected with the definite object of securing a wide range of variation in the $F_1$ and introducing, if possible, new characters that might be useful in the further evolution of economic sugarcane seedlings. The *Sorghum* cross was made to introduce a shorter life cycle than that in the sugarcane which occupies the land from 12 to even 24 months. *Sorghum* is a 4 to 6 months crop. Sugarcane types maturing in about 7 months from time of planting have been obtained. Some of these have shown high quality juices in spite of the *Sorghum* parentage and, what is more important from the agricultural view point, they are further showing ability to stand in the field without appreciable deterioration for fairly long periods after attaining maturity, in some cases even to as long as 4 months. The economic types secured from this hybridization have, however, been disappointing in their growth vigour.

Hybridization with the bamboo was attempted to introduce greater vigour, if possible, not only in the interspecific *Saccharum* hybrids but also in the comparatively early maturing Sugarcane × Sorghum hybrids. Bamboo hybridization was successfully done only in December 1936 and the first batch have not yet finished their full year life cycle. They are showing satisfactory growth vigour but it is too early to predict the possible economic results.

### *Dominance of Saccharum characters.*

The intergeneric hybrids above mentioned have shown some rather interesting phenomena with regard to the manner in which the characters are shown in the $F_1$ generation and transmitted in further back crosses with either parent. In both the *Sorghum* and Bamboo hybrids with sugarcane, the one fact that stands out prominently is the general dominance of *Saccharum* characters in the $F_1$. This is of great practical value to the sugarcane breeder who multiplies his improved canes by vegetative means. In the case of *Saccharum-Sorghum* hybrids

the general dominance of *Saccharum* characters was found to persist even after twice back crossing the hybrids with their *Sorghum* parent.

### *Appearance of new characters.*

Certain of the *Sorghum* hybrids exhibit characters not found in either parent; some of them carry leaves much thicker than either the sugarcane or the *Sorghum* parent and reminding one of the fleshy leaves of Crinum. Such characters get emphasized in further back crosses with *Sorghum*. Both the intergeneric hybrids above mentioned have also shown a very large number of abnormalities in stem, bud, leaf and the floral organs such as distorted, flattened or abnormal stems, double and multiple buds, partial suppression of lamina, forked leaves, multiple ovaries and multiple stigmas.

The *Saccharum-Sorghum* hybrids were mostly infertile in their first generation. On further vegetative propagation, however, some of them are showing an increasing fertility in the sexual organs with the result that, whereas in the earlier years no seeds could be obtained from them, it has since been possible to raise seedlings in large numbers from some of them and also back cross them with the two parents.

## VIII. Peculiarities of *Saccharum* Hybrids.

### *Distribution of parental characters.*

As already mentioned, the first characteristic noticed in the growing of sugarcane from seed is the very wide variation even in selfed seedlings in all characters, the root system, the stem, the leaf and its appendages and in sugar contents, the character for which this genus is cultivated.

This variation shows itself in a rather interesting manner in the $F_1$ hybrids. Taking as an example, the intergeneric hybrids between the sugarcane (P.O.J. 213) and the bamboo (*B. arundinacea*), the bamboo characters are found distributed in the various $F_1$ plants. Certain of them, for instance, show the early branching (characteristic of the bamboo), others the central cavity in the stem, yet others the ascending root eyes of the bamboo and so on. It has to be remembered that this behaviour has a very important bearing on the production of useful sugarcane types through hybridization. When this hybridization was first announced, one of the fears repeatedly expressed was that the hybrids may prove as hard as the bamboo and hence difficult to crush. The behaviour above described would ensure that, even if the extreme rind hardness of the bamboo is inherited, it is likely to show itself only in certain of the hybrids. If, therefore, the $F_1$ generation is raised in large numbers there is every chance of getting some without the bamboo hardness. The vegetative propagation in the present

case would again ensure that the bamboo hardness does not appear in the subsequent crop.

*Difficulty to repeat types.*

The second characteristic is the difficulty experienced in resynthesizing or rebuilding an improved cane that has once been obtained. This is deduceable from the variation already mentioned, but is perhaps worth illustrating in some detail.

During the season 1916 forty plants of the $F_1$ generation (Vellai × *S. spontaneum*) yielded in Co. 205 a cane of commercial value which it was possible to put straight into cultivation. This identical cross was repeated for at least four years and many thousands of seedlings of $F_1$ generation raised without being able either to reproduce or improve on Co. 205. Not only that; this $F_1$ hybrid was selfed for two successive generations and again many seedlings raised without being able to reproduce or improve upon the cane. A cane of the same type, but easily superior to it in many respects, was, however, secured in a somewhat roundabout way and by a complicated hybridization involving two canes of the thick or noble type and twice using *Saccharum spontaneum*. This is mentioned as illustrative of the large amount of chance or, as it has been called, the 'hit and miss' that is associated with the securing of results in sugarcane breeding.

*Absence of segregation.*

A third characteristic is the general absence of well-defined segregation of characters in *Saccharum* hybrids. This is attributed to certain unusual phenomena connected with the division and pairing of chromosomes yielding what are termed 'amphidiploids' or 'constant hybrids'. Even after carrying the process to more than three generations, types resembling the original parents have not been obtained.

*Hybrid fertility.*

Yet another peculiar characteristic of sugarcane hybrids is the absence of sterility among most interspecific hybrids. Even in the case of intergeneric hybrids it has been found that though the $F_1$ plants do exhibit sterility in the first year some of them produce fertile pollen after further vegetative propagation from cuttings and set seed freely.

*Chromosome behaviour.*

Fifthly, the chromosome behaviour in *Saccharum* presents certain rather unusual features. Dr. G. Bremer of Java was the first to work out the cytology of the sugarcanes. With

funds from the Imperial Council of Agricultural Research, somewhat intensive work on the subject has been in progress at Coimbatore under a special officer, Dr. E. K. Janaki Ammal, for the last three years. Properly controlled crosses have been made and are being studied and various interesting features associated with meiosis in the *Saccharum* are revealing themselves. This work is throwing light on the origin and distribution of *S. spontaneum* types, the probable origin of certain Indian canes and similar problems. The large numbers associated with *Saccharum* chromosomes—particularly in the later seedlings —render the work both difficult and time consuming. A fund of knowledge is waiting to be revealed when, besides the number, the study of chromosome morphology advances further than at present.

## IX. Economic and other Results.

There can be little doubt about the material benefits derived by the Sugar Industry of the world from hybridization in the genus *Saccharum*, both intervarietal and interspecific. The wide variations found in seedlings from the same parent—which are accentuated by hybridization—has supplied the Sugarcane Breeder with large numbers of new types. This has rendered the elimination and selection from such a variety of forms the prime work of the Sugarcane Breeder, once an $F_1$ generation from the mating of judiciously chosen parents has been secured.

The possibility of vegetative propagation of the improved types, which ensures the continuance in the subsequent crops of the characters for which the new cane was first selected, has been a great asset in securing quick results. Another asset of great importance and utility to the Cane Breeder is the free hybridization between the cultivated and wild types of *Saccharum*. All agriculture involves the growing of a single species or variety close together on a given piece of agricultural land which is somewhat unnatural. This introduces a general weakening of the plant resulting in the greater incidence of diseases and pests among other evils. The introduction of the wild species into the parentage has been useful in overcoming somewhat the disadvantages resulting from the above mentioned feature of agriculture. It is significant that such hybridization has, in the past, been of great value in introducing into the new productions both hardiness and resistance to diseases and other adverse conditions. Work on similar lines in the case of other crops wherever possible is one of the lessons of *Saccharum* to the other crop breeders.

The wide disparities that have been bridged by the intergeneric hybrids with *Saccharum* give food for thought and stimulus for further research. It may lead to a new orientation in the concept of *genus* and *species* at least in the genera and families allied to *Saccharum*. It engenders the feeling that, while perhaps

a great deal has been done in plant classification, further new light may yet be in store for the patient Researcher who can both describe his plants and also suitably hybridize them with one another.

# SECTION OF MEDICAL RESEARCH

*President* :—SIR U. N. BRAHMACHARI, KT., M.A., M.D., PH.D., F.N.I., F.R.A.S.B.

# *Presidential Address*

## THE CONQUEST OF KALA-AZAR AND CERTAIN OBSERVATIONS ON THE CHEMOTHERAPY OF MALARIA.

LADIES AND GENTLEMEN,

We are meeting under the most tragic circumstances. The sudden death of Lord Rutherford who was to be our General President has cast the deepest gloom over our Congress. The world has lost in him one of its most distinguished scientists who smashed the atoms, and though he breathes no more, his discoveries may one day enable one to travel to that mysterious region among the atoms and molecules wherein enters the breath of life. We express our deepest sense of sorrow to Lady Rutherford and the bereaved family. We are fortunate in having another most famous scientist as our General President and we have every reason to believe that under the guidance of Sir James Jeans, this momentous meeting of the Indian Science Congress will come to a successful issue.

I have chosen for my address the following subjects:

### THE CONQUEST OF KALA-AZAR AND CERTAIN OBSERVATIONS ON THE CHEMOTHERAPY OF MALARIA.

The earliest epidemic of kala-azar in Bengal occurred in the seventies of the last century, when it was probably complicated with malaria. As I stated elsewhere, in this epidemic it was noted by a contemporary writer that countries that once smiled with peace, health and prosperity had been turned into hot beds of disease, misery and death, and that the fell disease had mocked every human effort, and absorbed in its powerful grasp, day by day and inch by inch, every blessed spot which once used to be prized for its salubrity. This was the old Burdwan fever.

In more recent times the epidemic of the disease in Nowgong district of Assam produced such an appalling mortality that there was a decrease of 31·5 per cent. in population of the place in the decade 1891–1900.

The mortality from the disease has now been reduced from 90% or more to 1 or 2 per cent. Including complicated cases, it has been reduced from 99 to less than 10 per cent.

The conquest of kala-azar may be said to have begun when Cristina and Caronia obtained remarkable results in infantile kala-azar of the Mediterranean basin by the use of tartar emetic. Rogers introduced this drug into India for the treatment of Indian kala-azar and obtained similarly satisfactory results. Soon after the introduction of tartar emetic the speaker introduced sodium antimonyl tartrate for its treatment. This was taken up by others, as the compound was considered to be more powerful and less toxic than tartar emetic.

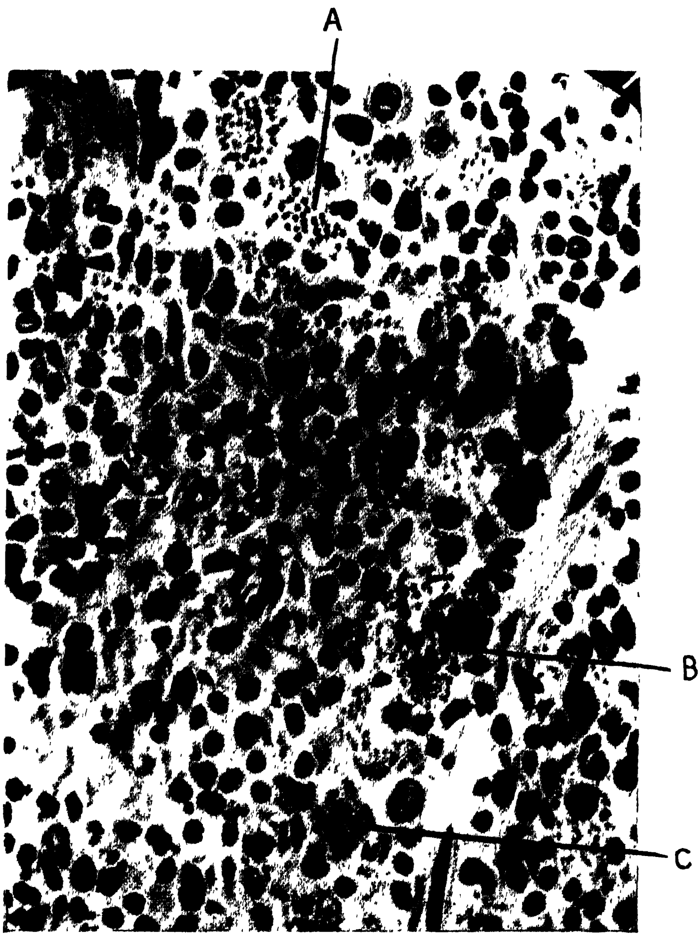
The next step in the treatment of the disease was the introduction by the speaker of intravenous injection of metallic antimony in a state of fine subdivision as an impalpable powder.

It has been observed (Brahmachari and co-workers) that when metallic antimony is injected intravenously in a state of fine subdivision, the particles are picked up by the same cells in the spleen as those that harbour the parasites of kala-azar and that in the struggle that ensues the fight ends most remarkably in the complete destruction of the parasites in the speediest way. (See Plate 5.)

A special outfit has been devised for the intravenous injection of metallic antimony.

The advantage of intravenous injection of metallic antimony is that the number of injections generally required is not more than three or four to bring about complete cure. It is one of the most powerful leishmanocides and may be tried in cases in which other antimonials have failed. The great objection to its use is the complicated technique of the operation of injection which is a serious obstacle in the mass treatment of the disease.

Although treatment with tartar emetic or sodium antimonyl tartrate was very successful in the treatment of kala-azar it was found that in the campaign against the disease it had the disadvantage of being long and tedious. In Assam which was once the hot bed of the disease, treatment was therefore found difficult to enforce, as patients discontinued treatment altogether or attended very irregularly after a few injections. This irregularity made it very difficult to effect complete cures. The Director of Public Health, Assam, once noted that in spite of the regulations in force under the Epidemic Diseases Act to compel patients to undergo a complete course of treatment, the campaign against the disease was greatly handicapped by the large number of patients who stopped treatment. To overcome this difficulty communiques were regularly issued inviting the co-operation of the people. Much propaganda work was done by means of lantern demonstrations and illustrated posters and pamphlets on the disease, emphasising the great dangers of stopping treatment before a complete cure was effected. Though this had some effect in reducing the 'Stopped Treatment' cases, still such cases continued to exist and it was felt that the difficulties in reducing the number of such cases would be overcome more




Photomicrograph of Spleen of a Mouse infected with *Leishmania Donovani* Forty-eight Hours after Intravenous Injection of Metalic Antimony.

A. Cell containing leishmania, but no particles of antimony.
B. Cell with faintly stained cytoplasm containing leishmania and a few particles of antimony.
C. Cell containing coarse granules of antimony and leishmania, some of which appear to be degenerated.

(Reproduced from a paper by the author and co-workers published in the *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Vol. XXIII, No. 6, April, 1930.)

effectively, if some drug could be introduced which would be more efficacious than tartar emetic and take a much shorter time to effect a cure.

The introduction of certain organic compounds of antimony in the treatment of kala-azar infection has been the subject of the speaker's research for many years, and in 1920 some of them were prepared for the first time in India in his laboratory in the Calcutta Campbell Hospital, and he wrote to the Indian Research Fund Association that the potentialities of the preparation of these compounds in India would in future be as great as those of cinchona plantation.

Early in 1921, the speaker discovered an urea antimony compound for the treatment of kala-azar. Its introduction and his other researches on antimonial compounds opened up a new vista in the treatment of the disease by means of therapeutic organic antimonials, just as the discovery of salvarsan led to the introduction of organic arsenicals in the treatment of spirochaetal diseases. This urea compound was named 'urea stibamine'. Soon after its discovery the author suggested to the Director of the Calcutta School of Tropical Medicine the possibility of obtaining therapeutic antimonials from Von Heyden and this led to their introduction into this institution for the treatment of kala-azar.

The first series of cases treated with urea stibamine were published early in 1922. Soon after this, remarkable results were obtained with it by Shortt in Shillong to whom the compound was sent for trial at the instance of the Director of Medical Research appointed by the Government of India. The value of this compound was quickly recognized and it was introduced, after an experimental trial, by the Government of Assam for the mass treatment of kala-azar.

I now proceed to demonstrate the value of urea stibamine in the campaign against kala-azar in Assam as obtained from statistics from the Annual Public Health Reports of the Government of Assam for the years 1925–35 and the Government Resolutions thereon. This drug has been more or less successively in use by the Government of Assam for over twelve years and today it is in universal use in the Province. For some time experiments with neostibosan were conducted side by side with urea stibamine. The use of neostibosan was subsequently discontinued.

In their resolution on the Annual Public Health Reports of the Province of Assam for the year 1926, the Government of Assam noted that the treatment with urea stibamine proved very successful and there was a very satisfactory decrease of over 1,000 in the number of 'Stopped Treatment' cases.

Figure 1 gives the number of cases of kala-azar treated in Assam as a whole from 1925 to 1935 showing a marked fall in the incidence of the disease from 60,940 in 1925 to 11,100 in 1935.

Figure 2 gives the death rate from kala-azar in Assam as a whole from the year 1925 to 1935 showing a marked fall from 6,365 in 1925 to 845 in 1935. Figure 3 gives the number of cases of kala-azar treated in the district of *Sylhet* during the same years showing a marked fall in the incidence of the disease from 10,934 in 1925 to 3,869 in 1935. Figure 4 gives the death rate from the disease in the district of Sylhet from the year 1925 to 1935 showing a marked fall from 2,109 in 1925 to 260 in 1935. Figure 5 gives the number of cases of kala-azar treated in the district of *Goalpara* during the same years showing a marked fall in the incidence of the disease from 6,003 in 1925 to 1,245 in 1935. Figure 6 gives the death rate from the disease from the same years in *Goalpara* showing a marked fall from 453 in 1925 to 100 in 1935. Figure 7 gives the number of cases of the disease treated in the district of *Kamrup* during the same years showing a marked fall in the incidence of the disease from 8,753 in 1925 to 1,465 in 1935. Figure 8 gives the death rate for the same years in the district of *Kamrup* from the years 1925 to 1935 showing a marked fall from 1,120 in 1925 to 176 in 1935. Figure 9 gives the number of cases treated in the district of *Darrang* during the same years showing a marked fall in the incidence of the disease from 5,262 in 1925 to 738 in 1935. Figure 10 gives the death rate for the same years in the district of *Darrang* for the years 1925 to 1935 showing a marked fall from 478 in 1925 to 91 in 1935. Figure 11 gives the number of cases treated in the district of *Nowgong* during the same years showing a marked fall in the incidence of the disease from 13,895 in 1925 to 1,651 in 1935. Figure 12 gives the death rate from the disease for the same years in the district of *Nowgong* showing a marked fall from 1,445 in 1925 to 52 in 1935. Figure 13 gives the number of cases treated in the *Garo Hills* during the same years showing a marked fall in the incidence of the disease from 1,952 in 1925 to 690 in 1935. Figure 14 gives the death rate from the disease for the same years in the *Garo Hills* showing a marked fall from 435 in 1925 to 58 in 1935.

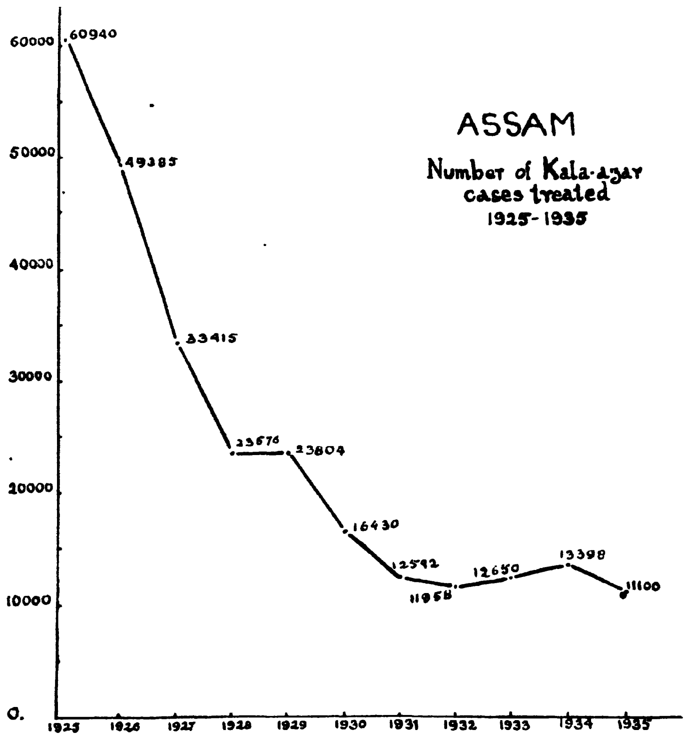

ASSAM
Number of Kala-azar cases treated
1925-1935
60000
50000
40000
30000
20000
10000
0.
60940
49385
33415
23676
23804
16430
12592
11958
12650
13398
11100
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 1.

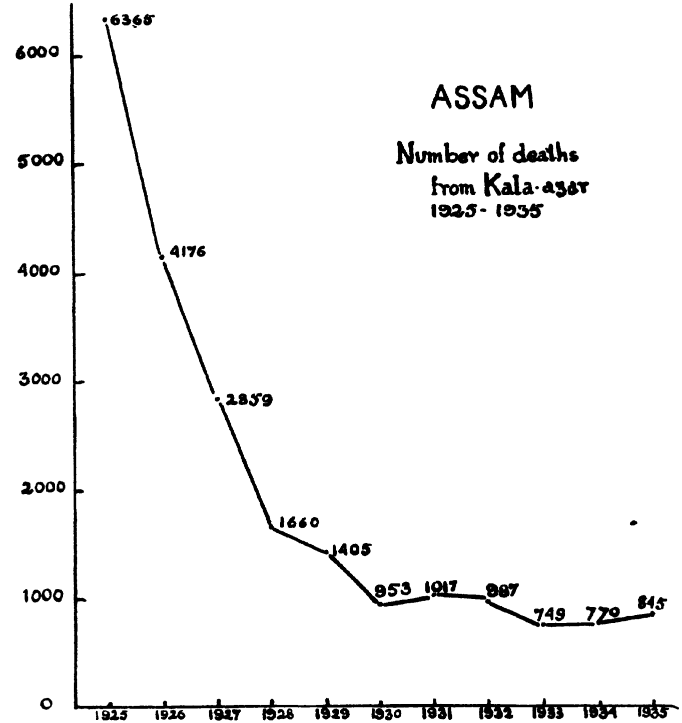
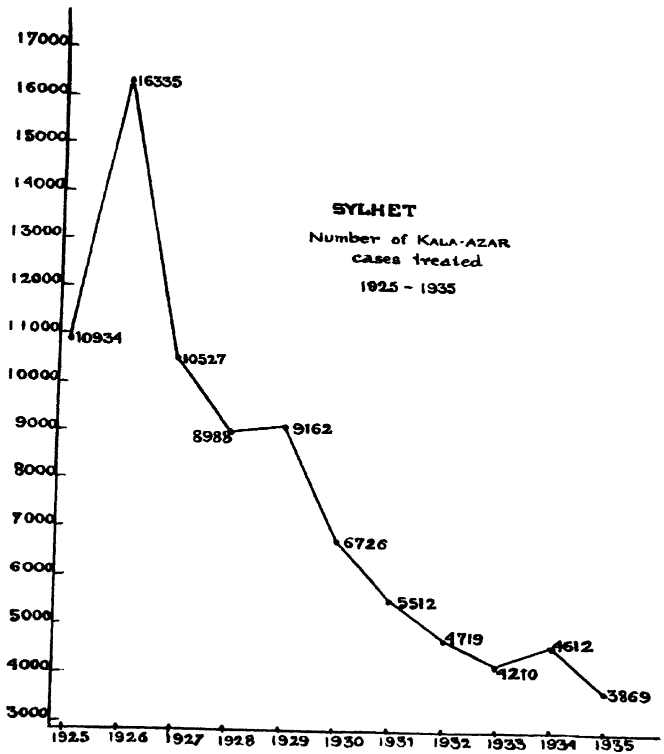
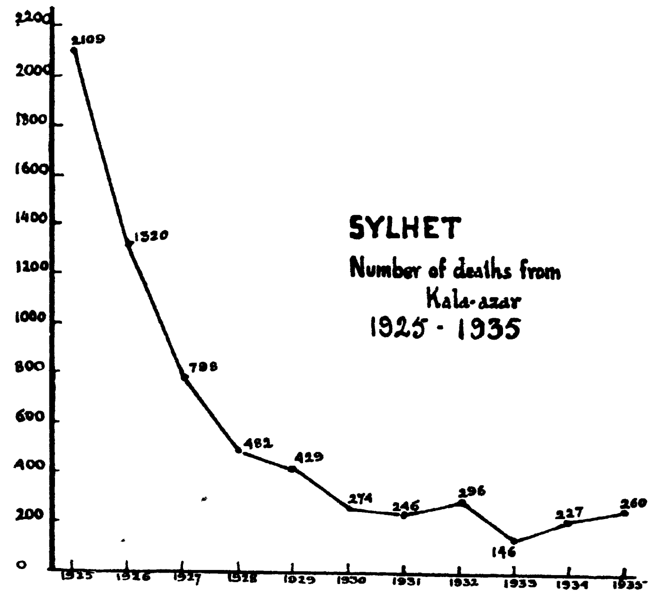

ASSAM
Number of deaths from Kala-azar
1925-1935
6000
5000
4000
3000
2000
1000
0
6365
4176
2859
1660
1405
953
1017
987
749
779
845
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 2.


SYLHET
Number of KALA-AZAR cases treated
1925 - 1935
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
10934
16335
10527
8988
9162
6726
5512
4719
4210
4612
3869
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935


SYLHET
Number of deaths from Kala-azar
1925 - 1935
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2109
1320
788
482
429
274
246
296
146
227
260

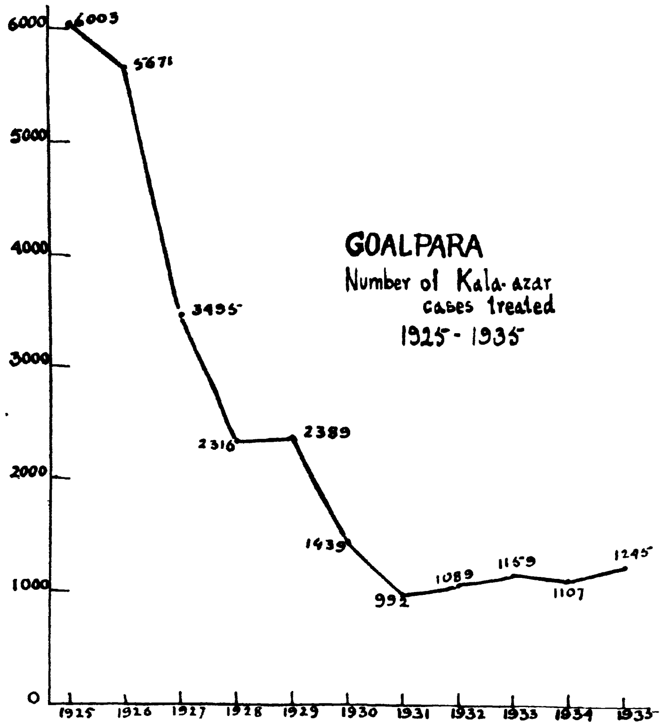

GOALPARA
Number of Kala-azar cases treated
1925-1935
6000
5000
4000
3000
2000
1000
0
6003
5671
3495
2316
2389
1439
992
1089
1159
1107
1245
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 5.

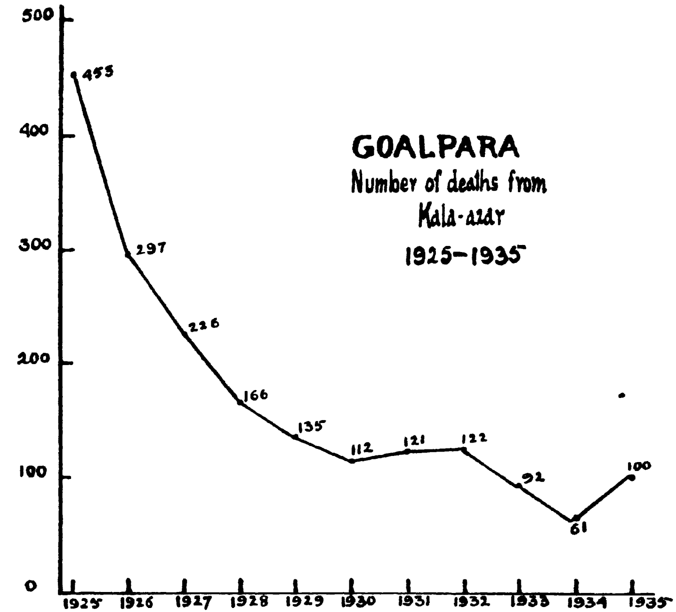

GOALPARA
Number of deaths from Kala-azar
1925-1935
500
400
300
200
100
0
455
297
226
166
135
112
121
122
92
61
100
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 6.

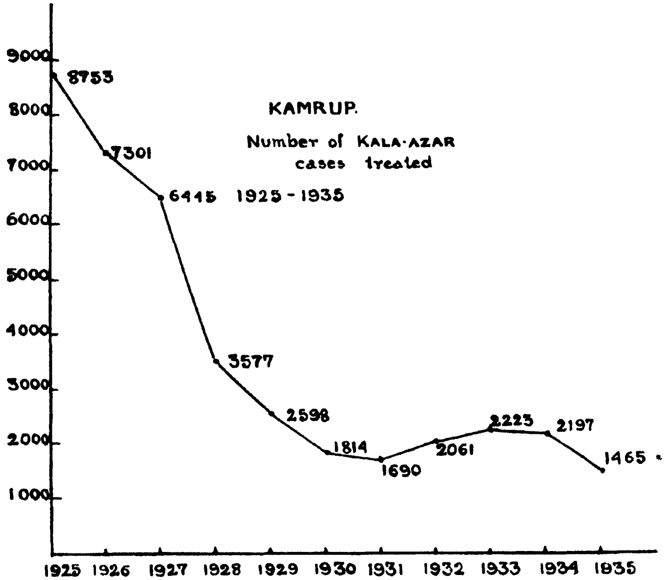

KAMRUP.
Number of KALA-AZAR cases treated
1925 - 1935
9000
8000
7000
6000
5000
4000
3000
2000
1000
8753
7301
6445
3577
2598
1814
1690
2061
2225
2197
1465
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 7.

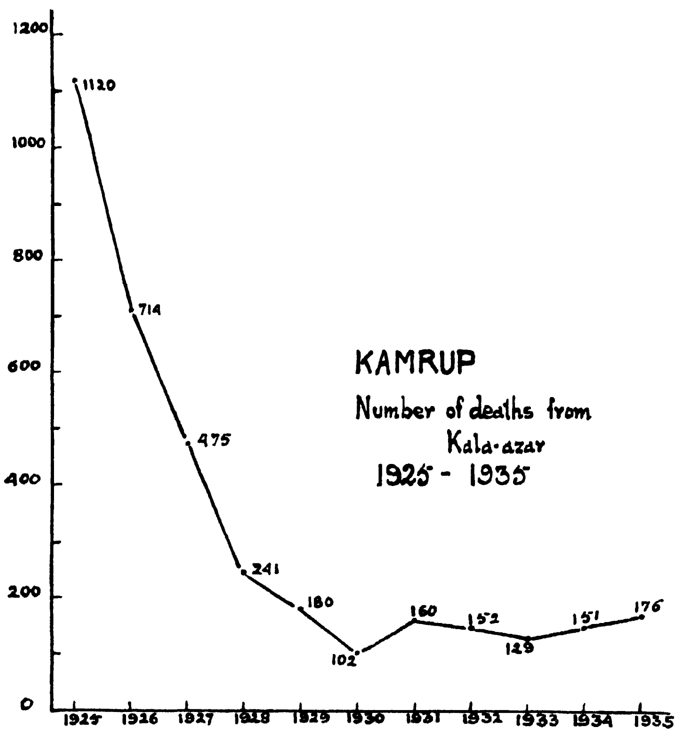

KAMRUP
Number of deaths from Kala-azar
1925 - 1935
1200
1000
800
600
400
200
0
1120
714
475
241
180
102
160
152
129
151
176
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 8.

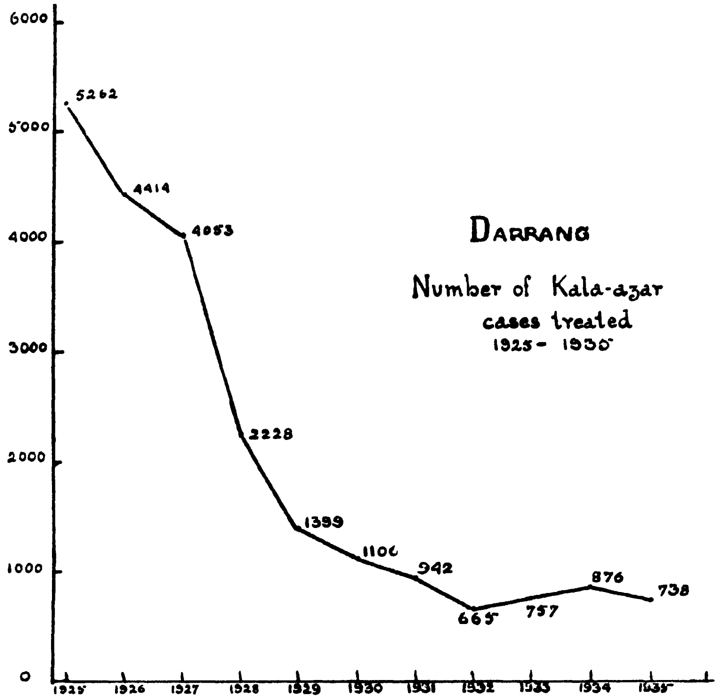

DARRANG
Number of Kala-azar cases treated
1925 - 1935
6000
5000
4000
3000
2000
1000
0
5262
4414
4053
2228
1399
1106
942
665
757
876
738
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 9.

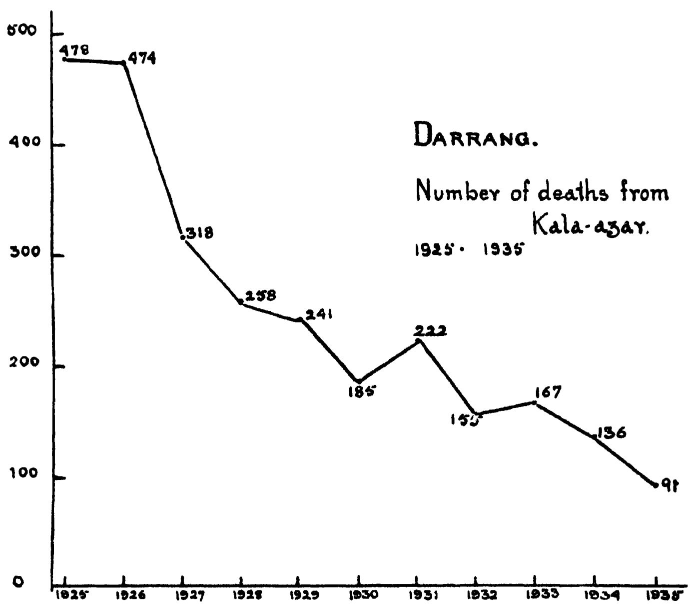

DARRANG.
Number of deaths from Kala-azar.
1925 - 1935
500
400
300
200
100
0
478
474
318
258
241
185
222
155
167
136
91
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 10.

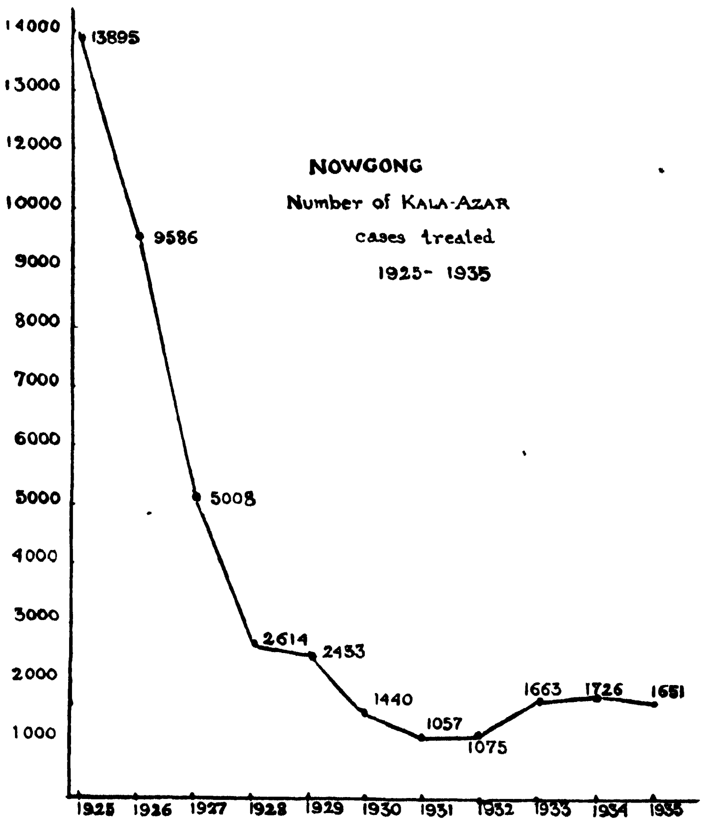

NOWGONG
Number of KALA-AZAR
cases treated
1925- 1935
14000
13000
12000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
13895
9586
5008
2614
2453
1440
1057
1075
1663
1726
1651
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 11.

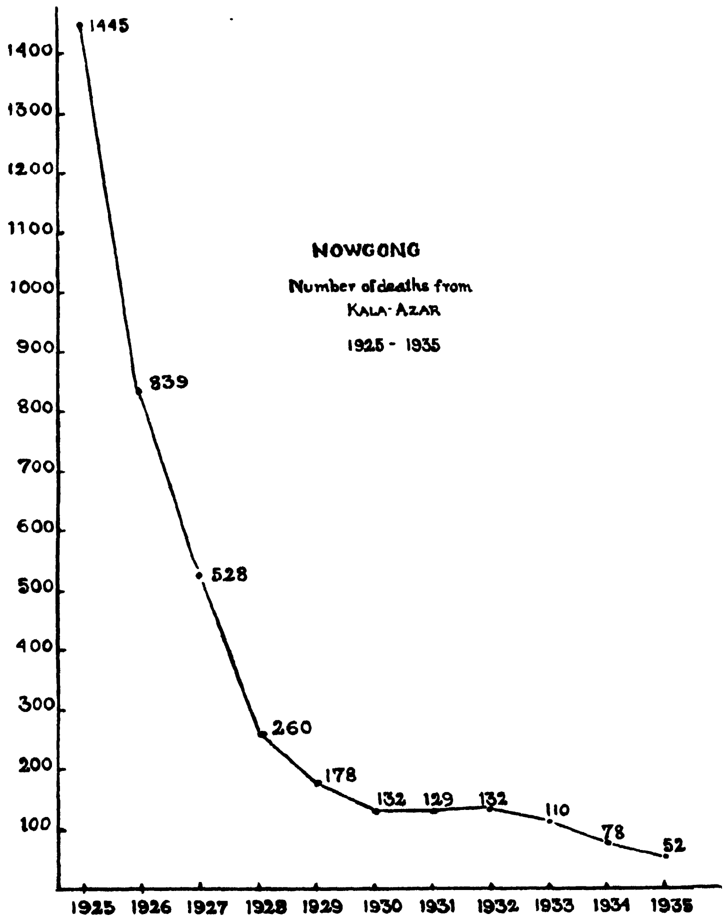
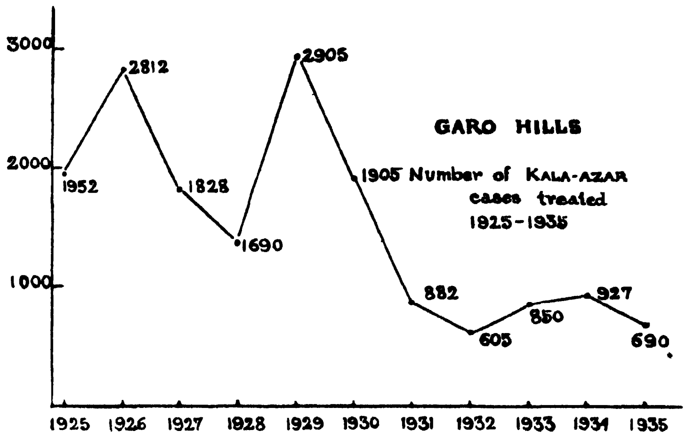
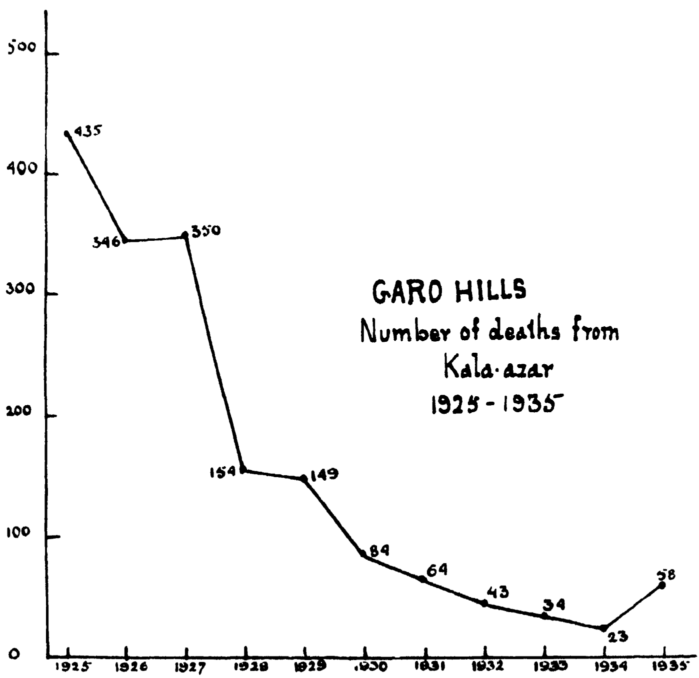

NOWGONG
Number of deaths from
KALA-AZAR
1925 - 1935
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
1445
839
528
260
178
132
129
132
110
78
52
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935

FIG. 12.



3000
2000
1000
2812
2905
1952
1828
1690
1905
882
605
850
927
690
GARO HILLS
Number of KALA-AZAR cases treated 1925-1935
1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935


FIG. 13.



500
400
300
200
100
0
435
346
350
154
149
84
64
43
34
23
58
GARO HILLS
Number of deaths from Kala-azar 1925-1935
1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935


FIG. 14.

## STATISTICS OF NUMBER OF KALA-AZAR CASES TREATED BY THE GOVERNMENT OF ASSAM AND THE NUMBER OF DEATHS FROM THE DISEASE

### Province of Assam as a whole

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 60,940 | 49,385 | 33,415 | 23,576 | 23,804 | 16,430 | 12,592 | 11,958 | 12,650 | 13,398 | 11,100 |
| No. of deaths .. | 6,365 | 4,176 | 2,859 | 1,660 | 1,405 | 953 | 1,017 | 987 | 749 | 770 | 845 |

### Districts

#### *Sylhet*

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 10,934 | 16,335 | 10,527 | 8,988 | 9,162 | 6,726 | 5,512 | 4,719 | 4,210 | 4,612 | 3,869 |
| No. of deaths .. | 2,109 | 1,320 | 798 | 482 | 429 | 274 | 246 | 296 | 146 | 227 | 260 |

#### *Goalpara*

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 6,003 | 5,671 | 3,495 | 2,316 | 2,389 | 1,439 | 992 | 1,089 | 1,159 | 1,107 | 1,245 |
| No. of deaths .. | 453 | 297 | 226 | 166 | 135 | 112 | 121 | 122 | 92 | 61 | 100 |

*Kamrup*

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 8,753 | 7,301 | 6,445 | 3,577 | 2,598 | 1,814 | 1,690 | 2,061 | 2,223 | 2,197 | 1,465 |
| No. of deaths .. | 1 120 | 714 | 475 | 241 | 180 | 102 | 160 | 152 | 129 | 151 | 176 |

*Darrang*

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 5.262 | 4,414 | 4,053 | 2,228 | 1,399 | 1,106 | 942 | 665 | 757 | 876 | 738 |
| No. of deaths .. | 478 | 474 | 318 | 258 | 241 | 185 | 222 | 155 | 167 | 136 | 91 |

*Nowgong*

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 13,895 | 9,586 | 5,008 | 2,614 | 2,433 | 1,440 | 1,057 | 1,075 | 1,663 | 1.726 | 1,651 |
| No. of deaths .. | 1,445 | 839 | 528 | 260 | 178 | 132 | 129 | 132 | 110 | 78 | 52 |

*Garo Hills*

| Year | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases treated | 1,952 | 2,812 | 1,828 | 1,690 | 2,905 | 1,905 | 882 | 605 | 850 | 927 | 690 |
| No. of deaths .. | 435 | 346 | 350 | 154 | 149 | 84 | 64 | 43 | 34 | 23 | 58 |

The number of cases treated and of deaths in 1936 could not be incorporated in the above Figures and Tables, as the Annual Health Report for 1936 was not available when the figures and tables were printed off. Fig. 15 gives a comparative

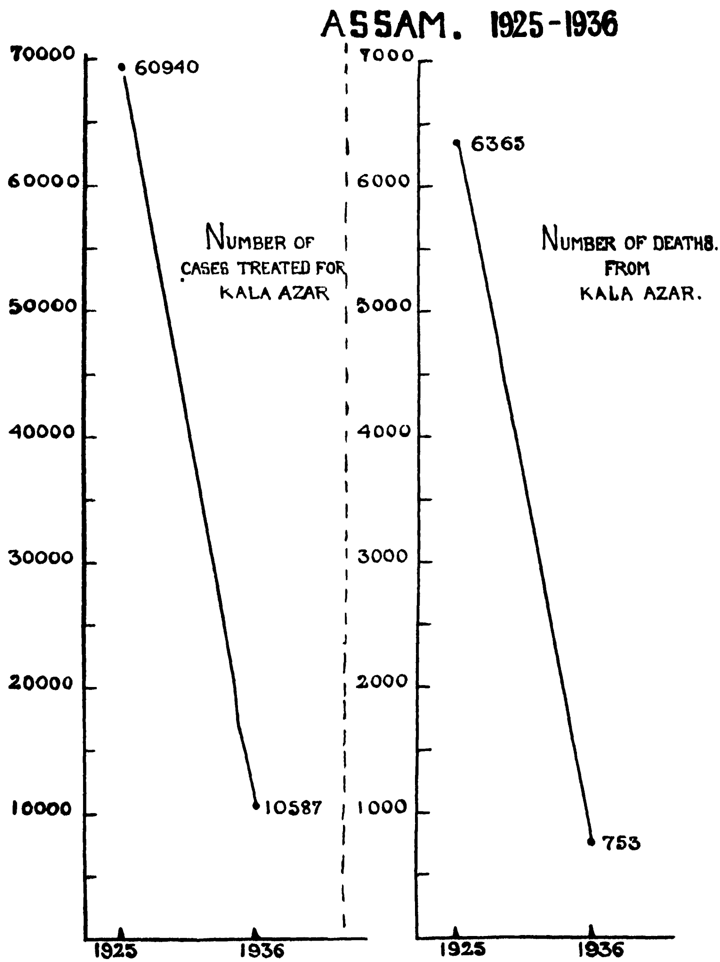



FIG. 15.

statement of the number of cases treated and deaths in the Province of Assam from 1925 to 1936.

The figures for Cachar which are not exhibited in the above diagrams are very interesting. Out of 5,188 cases treated from 1925 to 1936, the number of deaths was 56 showing a percent-

age of less than 1·08 per cent. Out of 574 cases treated in 1936 the number of deaths was 2 showing a percentage of less than 0·3 per cent.

It will be seen from the above Figures and Tables that the effect of the treatment with urea stibamine during the above mentioned years on the incidence of kala-azar in Assam and its mortality has been phenomenal. The disease has lost all its terrors in the Province and people who suffer from it are less afraid than those who suffer from malaria.

The Kala-azar Commission, India, used, throughout the seven years of their existence, urea stibamine only, in the routine treatment of kala-azar. According to them the acute fulminating type characteristic of the peak period of an epidemic responded to treatment with urea stibamine extraordinarily promptly and with an almost dramatic cessation of fever, diminution in size of the spleen and return to normal condition of health. It may be expected that similar beneficial results will be obtained in other epidemics of the disease.

In 1933, the Director of Public Health, Assam, noted that 'urea stibamine was our mainstay in the treatment of kala-azar'. 'Since 1923, when reliable figures for the diseases first became available to end of the year under report, no less than 328,591 persons have been brought under treatment. It is no exaggeration to say that approximately 3·25 lacs of valuable lives have been saved to the Province.'

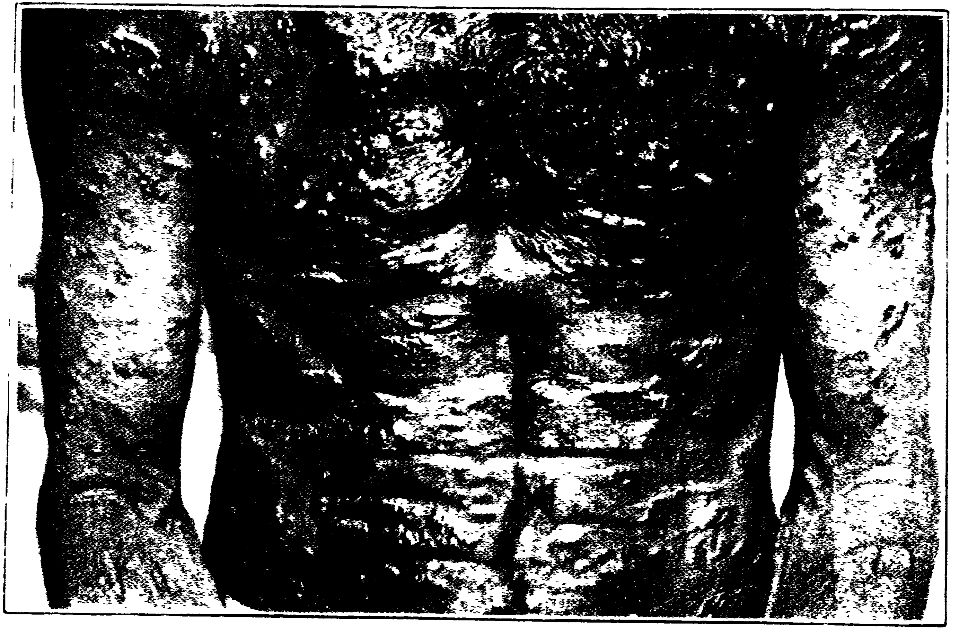
Sir John Kerr, once Governor of Assam in his farewell address to the Assam Legislative Council referring to the value of urea stibamine stated that 'the progress in the campaign against kala-azar in Assam has been phenomenally rapid and if it continues at the present rate there is an excellent prospect of the dread scourge being brought under complete control in a few years'. This has now come to pass, as you have just seen from the statistics quoted in the present address, and as was once predicted by the Director of Public Health, Assam, one day we shall be successful in stamping the disease out of the Province. The same may also be said of other parts of the world where the disease occurs. The discovery of a powerful specific for the disease, its limited distribution and rarity of relapses lend support to this conclusion.

A few antimonials have been tried intramuscularly in the treatment of kala-azar. Among these may be mentioned sodium-N-phenyl-glycine-amide-4-stibinate (antimony analogue of tryparsamide) and sodium-sulphomethylene-stibanilate (antimony analogue of sulph-arsenol) which have been successfully used by the author, while neostibosan has been used with success by Napier.

In studying the treatment of kala-azar one finds that the enemy in the process of destruction tries to retreat from the internal organs to some other parts of body, just as it is noticed

[illegible] of Dermal Leishmanoid

(Reproduced from a paper by the author published in the *Indian Medical Gazette*, Vol. LVII, No.
April 1922)



Showing extensive annular lesions in trunk in front and the arm.

(Reproduced from a paper by P. N. Brahmachari published in the *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Vol. XXVIII No. 2, August, 1934.)

in the case of human warfare the conquered foe tries to hide himself in hills and jungles to elude the pursuit of the conquerors. This was first discovered in 1922 when the speaker observed certain remarkable skin eruptions caused by *Leishmania donovani* developing in kala-azar patients two or three years after completion of antimonial treatment and apparent cure, though under ordinary conditions, in kala-azar the skin shows very little involvement or none. Originally considered very rare, these skin lesions have been subsequently found not to be an uncommon condition.

The disease was named dermal leishmanoid by the speaker when first discovered, and subsequently called dermal leishmaniasis in the Carmichael Hospital for Tropical Diseases attached to the Calcutta School of Tropical Medicine.

The various types of the disease will not be described here in detail.

The photographs of the first recorded case of dermal leishmanoid as well as of a case of annular variety of the disease are reproduced here (Plates 6 and 7).

The photomicrographs of sections of skin showing the presence of leishmania-laden cells just under the epidermal layer and of leishmania-laden pigment-carrying cells in the superficial layer of the dermis are shown in Plate 8.

Viable leishmania have been cultured from these skin lesions in test tubes and sandflies. They are therefore a source of infection and the conquest of kala-azar cannot be regarded complete unless these lesions are either averted or quickly cured. Not infrequently, they take a prolonged course of antimonial treatment and some of them are very resistant and may be dangerous carriers of antimony-resistant parasites. The author has recommended combined treatment with intravenous injection of urea stibamine and inunction of metallic antimony.

It is evident that in the campaign against kala-azar and its conquest, proper handling of cases of dermal leishmanoid is an important point to be taken into consideration.

The constitution of urea stibamine has been a matter of some controversy. As pointed out by Gray and co-workers it is the most interesting of therapeutic antimonials. Originally considered by the speaker to be urea salt of para-amino-phenyl stibinic acid, it was subsequently considered by him to be ammonium carbamino-stibanilate. More recently Gray and co-workers have studied the chemical constitution and physiological properties of the compound carefully and exhaustively in an important paper in the *Proceedings of the Royal Society* (1931). They have shown that urea stibamine is disubstituted urea consisting mostly of S-diphenylcarbamide-4 : 4'-distibinic acid as its active organo-metallic constitution, containing some amount of protective colloids to make it water-soluble. Its constitution is

therefore, according to these observers, different from that of compounds of the type of neostibosan or neostam which are salts of para-aminophenyl-stibinic acid.

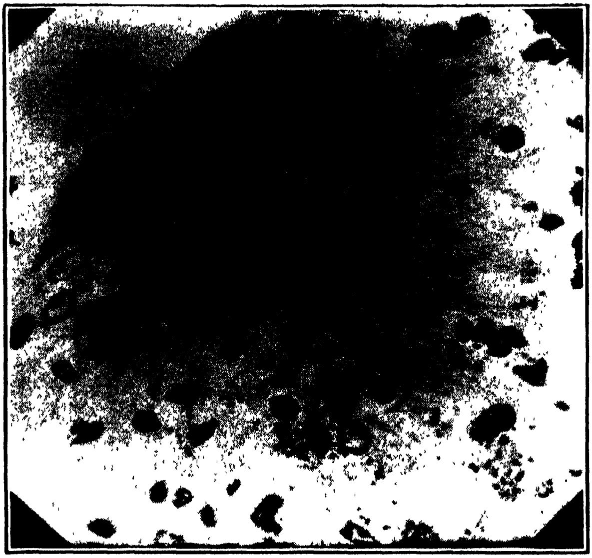
The conquest of kala-azar by campaign against the disease by treatment of the affected individuals is, from what I have shown, one of the most remarkable feats in chemotherapy. Whether a prophylactic dose of urea stibamine to persons living in kala-azar infected areas just like the prophylactic use of quinine in malaria will be of any value or whether an inunction of metallic antimony may be recommended to be used by them as a routine practice is a matter of investigation.

*
* *

I now pass on from the conquest of kala-azar, to certain observations on the chemotherapy of antimalarial quinoline and acridine compounds, which may one day play an important part in the campaign against malaria and its conquest.

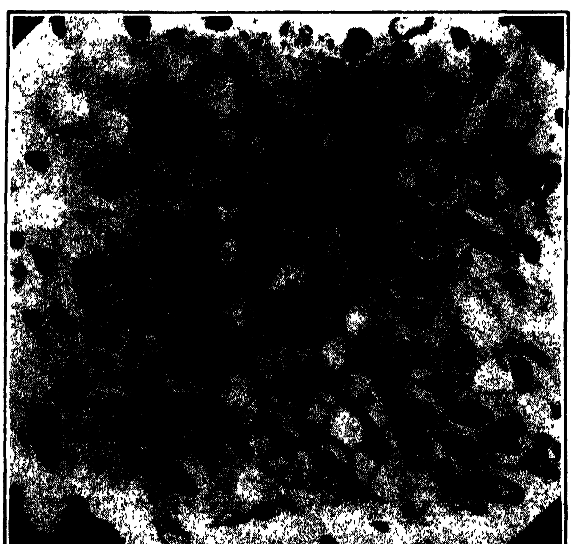
In most of the Eastern parts of India malaria and kala-azar go together. They have many symptoms in common and were confused with each other for a long time.

Research in chemotherapy of malaria has been intense in recent times. In certain parts of India it is of greater interest than kala-azar. For sometime past, work in this line has been undertaken by the speaker and co-workers and new quinoline compounds synthesized with the view of studying their action on paramoecia as well as on the parasites of malaria. While, as will be seen from the accompanying tables, some of these compounds have marked destructive action on paramoecia, most of them have been observed to have no action on the parasites of malaria when used clinically in patients suffering from the disease.



Photomicrograph of a section of the skin showing leishmania-laden cells just under the epidermal layer.

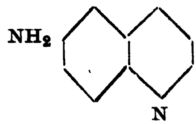
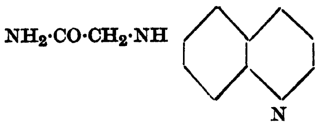
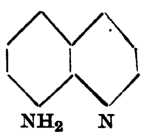
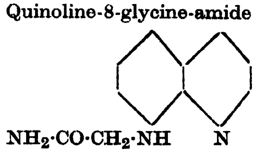
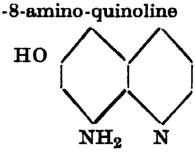
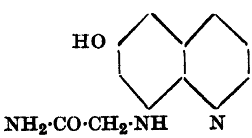
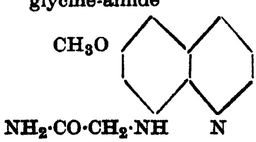
(P. N. Brahmachari.)



Photomicrograph of a section of the skin showing leishmania laden pigment-carrying cells in the superficial layer of dermis.

(P. N. Brahmachari.)

*Action of certain quinoline compounds on paramoecia*

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| I. 6-amino-quinoline   | 1 : 2,000<br>1 : 4,000 | Death<br>No death |
| II. Quinoline-6-glycine-amide   | 1 · 2,000<br>1 . 4,000 | Death<br>No death |
| III. 8-amino-quinoline   | 1 : 2,000<br>1 : 4,000 | No death<br>No death |
| IV. Quinoline-8-glycine-amide   | 1 : 2,000 | No death |
| V. 6-oxy-8-amino-quinoline   | 1 : 2,000<br>1: 10,000<br>1 : 20,000<br>1 : 40,000<br>1 : 80,000<br>1 : 160,000<br>1 : 320,000 | Death in 6 minutes<br>Death in 7 minutes<br>Death in 7 minutes<br>Death in 8 minutes<br>Death in 14 minutes<br>Death in 17 minutes<br>No death in 1 hour |
| VI. 6-oxy-quinoline-8-glycine-amide   | 1 : 200<br>1 : 10,000<br>1 : 20,000<br>1 : 40,000<br>1 : 80,000<br>1 : 160,000<br>1 : 320,000 | Death in 7 minutes<br>Death in 7 minutes<br>Death in 10 minutes<br>Death in 11 minutes<br>Death in 15 minutes<br>Death in 19 minutes<br>No death |
| VII. 6-methoxy-quinoline-8-glycine-amide   | 1 : 1,000 | No action |

For purpose of comparison we append here the action of quinine hydrochloride on paramoecia under conditions similar to the above.

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| Quinine hydrochlor | 1 : 10,000 | Death in 5 minutes |
| | 1 : 20,000 | Death in 10 minutes |
| | 1 : 40,000 | Death in 19 minutes |
| | 1 : 80,000 | Death in 35 minutes |
| | 1 : 160,000 | No death in 1 hour |

(Reproduced from a paper by the author and co-workers published in the *Journal of Pharmacology and Experimental Therapeutics,* Vol. XXXIX, No. 4, August, 1930.)

TABLE II

*Action of certain quinoline compounds on paramoecia*

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| I. 6-amino-4-phenyl-quinaldine hydrochloride | 1 : 2,000 | No death in 1 hour |
| | 1 : 10,000 | No death in 1 hour |
| II. 8-amino-4-phenyl-quinaldine hydrochloride | 1 : 2,000 | Death in 4 minutes |
| | 1 : 10,000 | Death in 24 minutes |
| | 1 : 20,000 | A few dead in 1 hour |
| | 1 : 40,000 | No death in 1 hour |

(Reproduced from a paper by the author and co-workers published in the *Journal of Pharmacology and Experimental Therapeutics,* Vol. XLI, No. 3, March, 1931.)

TABLE III

*Action of certain quinoline compounds on paramoecia*

| | Strength | Effect on paramoecia |
|---|---|---|
| 1. 8-amino-quinoline-para-arsanilate | 1 : 2,000 | A few death in 1 hour |
| | 1 : 10,000 | No death in 1 hour |
| 2. 6-amino-quinoline-para-arsanilate | 1 : 2,000 | No death in 1 hour |
| | 1 : 10,000 | No death in 1 hour |
| 3. 8-amino-ethyl-amino-quinoline hydrochloride (Robinson) | 1 : 2,000 | Death in 3 minutes |
| | 1 : 10,000 | Death in 29 minutes |
| | 1 : 20,000 | No death in 1 hour |
| 4. 8-amino-isopropyl-amino-quinoline hydrochloride | 1 : 2,000 | Death in 20 minutes |
| | 1 : 10,000 | Death in 35 minutes |
| | 1 : 20,000 | 90 per cent. death in 1 hour |
| | 1 : 40,000 | No death in 1 hour |
| 5. 6-methoxy-8-amino-iso-propyl-amino-quinoline di-hydrochloride | 1 : 2,000 | A few dead in 1 hour |
| | 1 : 10,000 | No death in 1 hour |
| 6. 6-chloro-8-amino-isopropyl-amino-quinoline di-hydro-chloride | 1 : 2,000 | Death in 1 minute |
| | 1 : 10,000 | Death in 4 minutes |
| | 1 : 20,000 | Death in 12 minutes |
| | 1 : 40,000 | Death in 30 minutes |
| | 1 : 80,000 | No death in 1 hour |
| | 1 : 100,000 | No death in 1 hour |
| 7. 6-chloro-2-methyl-8-amino-isopropyl-amino-quinoline di-hydrochloride | 1 : 2,000 | Death in 30 minutes |
| | 1 : 10,000 | No death in 1 hour |
| 8. Amino-acetyl derivative of 8-amino-ethyl-amino quinoline | 1 : 2,000 | 90 per cent. death in 1 hour |
| | 1 : 10,000 | No death in 1 hour |

(Reproduced from a paper by P. Brahmachari, U. Brahmachari and R. Banerjea published in the *Journal of Pharmacology and Experimental Therapeutics*, Vol. XLIV, No. 4, April, 1932.)

TABLE IV

*Action of certain quinoline compounds on paramoecia*

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| 1. Allyl-8-amino-quinoline hydrochloride | 1 : 2,000<br>1 : 10,000 | Death in 5 minutes<br>No death in 1 hour |
| 2. Allyl-thio-carbamino-8-amino-quinoline hydrochloride | 1 : 2,000<br>1 : 10,000 | No death in 1 hour<br>No death in 1 hour |
| 3. 6-methoxy-8-β-dimethyl-amino-isopropyl-amino-quinoline dihydrochloride | 1 : 2,000<br>1 : 10,000 | Death in 14 minutes<br>No death in 1 hour |
| 4. 6-methyl-8-β-dimethyl-amino-isopropyl-amino-quinoline dihydrochloride | 1 : 2,000<br>1 : 10,000 | Death in 1 hour<br>No death in 1 hour |
| 5. 2-methyl-6-methoxy-8-β-dimethyl-amino-iso-propyl-amino-quinoline dihydrochloride | 1 : 2,000<br>1 : 10,000<br>1 : 20,000 | Death in 28 minutes<br>Death in 1 hour<br>No death in 1 hour |
| 6. Lactyl-8-amino-quinoline hydrochloride | 1 : 2,000<br>1 : 10,000<br>1 : 20,000<br>1 : 40,000<br>1 : 80,000 | Death in 12 minutes<br>Death in 28 minutes<br>Death in 35 minutes<br>Death in 1 hour<br>No death in 1 hour |
| 7. β-hydroxy-propyl-8-amino-quinoline hydrochloride | 1 : 2,000<br>1 : 10,000 | Death in 45 minutes<br>No death in 1 hour |
| 8. 6-ethoxy-β-hydroxy-propyl-8-amino-quinoline-hydrochloride | 1 : 2,000<br>1 : 10,000 | No death in 1 hour<br>No death in 1 hour |
| 9. 6-ethoxy-lactyl-8-amino-quinoline-hydrochloride | 1 : 2,000<br>1 : 10,000 | Death in 18 minutes<br>No death in 1 hour |
| 10. 6-methoxy-8-β-diethyl-amino-isopropyl-amino-quinoline dihydrochloride | 1 : 2,000<br>1 : 10,000 | No action in 1 hour<br>No action in 1 hour |
| 11. 8-(β-piperidino-isopropyl-amino)-quinoline dihydrochloride | 1 : 2,000<br>1 : 10,000<br>1 : 20,000<br>1 : 40,000<br>1 : 80,000<br>1 : 100,000 | Immediate death<br>Death in 2 minutes<br>Death in 10 minutes<br>Death in 11 minutes<br>Death in 15 minutes<br>Death in 35 minutes |

(Reproduced from a paper by P. Brahmachari, R. Banerjea, and U. Brahmachari published in the *Journal of Pharmacology and Experimental Therapeutics*, Vol. XLVIII, No. 2, June, 1933.)

Apart from the variability in the value of the hitherto-known quinoline and acridine derivatives in their destructive action on the different types of malarial parasites or on the schizonts and gametocytes of the same parasite or its strains, these compounds sometimes exhibit toxic symptoms of varying intensity and this is sufficient justification for further research on synthetic antimalarials.

Of late, a compound having the same composition as quinacrine or atebrin has been synthesized in the speaker's laboratory.

As expected, it has well-marked antimalarial properties as will be presently seen. It is provisionally named Acridin X or Ax. The compound has been used by the speaker as hydrochloride or hydrobromide. The following is the first series of cases treated in the Tropical Diseases Ward of the Carmichael Medical College Hospitals, Calcutta. Its action on paramoecia is shown in the accompanying table. Its action in monkey malaria has been studied by Shortt and Menon.

ACTION OF ACRIDIN X ON PARAMOECIA

*Experiment No. I*

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| Acridin X | 1 : 1,000 | Death in 2 to 4 minutes |
| | 1 : 5,000 | Death in 4 to 6 minutes |
| | 1 : 10,000 | Death in 8 to 10 minutes |
| | 1 : 40,000 | Death in 12 to 15 minutes |
| | 1 : 80,000 | Majority died in ¾ of an hour |
| | 1 : 100,000 | Majority died in 1¼ of an hour |
| | 1 : 120,000 | Few deaths in 1½ of an hour |
| | 1 : 160,000 | No death in 2 hours. |

*Experiment No. II*

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| Acridin X | 1 : 1,000 | Death in 3 minutes |
| | 1 : 5,000 | Death in 3 to 5 minutes |
| | 1 : 10,000 | Death in 7 to 10 minutes |
| | 1 : 40,000 | Death in 10 to 14 minutes |
| | 1 : 80,000 | Majority died in 1½ hours |
| | 1 : 100,000 | Majority died in 1½ of an hour |
| | 1 : 120,000 | Few deaths in 2 hours. |
| | 1 : 160,000 | No death in 2½ hours |

*Experiment No. III*

| | STRENGTH | EFFECT ON PARAMOECIA |
|---|---|---|
| Acridin X | 1 : 1,000 | Death in 2 to 5 minutes |
| | 1 : 5,000 | Death in 4 to 6 minutes |
| | 1 : 10,000 | Death in 6 to 9 minutes |
| | 1 : 40,000 | Death in 10 to 15 minutes |
| | 1 : 80,000 | Majority died in 62 minutes |
| | 1 : 100,000 | Majority died in 1½ hours (few survived) |
| | 1 : 120,000 | Few deaths in 2 hours |
| | 1 : 160,000 | No death in 2½ hours |

## *A Series of Cases of Malarial Fever treated with Acridin X.*

*No I.*—Patient K, aet 25, was admitted on 4-2-37. History of fever for two months. Patient was put on Ax from 5-2-37 in 1½ grs. doses thrice a day. The effect of the treatment is shown in Chart I. On 4-2-37, B.T. trophozoites were present in blood; on 7-2-37, no malarial parasites were found; on 4-2-37, spleen was 3″ below costal margin; on 11-2-37, spleen was just felt below costal margin.

*No. II.*—Patient B, aet 20, was admitted on 13-1-37. History of fever for 15 days. Patient was put on Ax from 14-1-37 in 1½ grs. doses thrice a day. The effect of the treatment is shown in Chart II. On 13-1-37, B.T. trophozoites and gametocytes were present in blood; on 17-1-37, no malarial parasites were found; on 13-1-37, spleen was 1½″ below costal margin; on 8-2-37, spleen was not palpable below costal margin.

*No. III.*—Patient D, aet 18, was admitted on 9-11-36. History of fever for two months. Patient was put on Ax from 12-11-36 in 2¼ grs doses thrice a day. The effect of the treatment is shown in Chart III. On 10-11-36, B.T. and M.T. trophozoites were present in blood; on 13-11-36, no malarial parasites were found; on 9-11-36, spleen was hard and 2″ below costal margin; on 17-2-37, spleen was just felt below costal margin.

*No. IV.*—Patient C, aet 16, was admitted on 2-3-37. History of fever for 2½ months. Patient was put on Ax from 3-3-37 in 1½ grs. doses thrice a day. The effect of treatment is shown in Chart IV. On 3-3-37, M.T. rings and crescents were present in the blood; on 7-3-37, only crescents were found; on 2-3-37, spleen was 1″ below costal margin; on 8-4-37, spleen was just felt below costal margin.

*No. V.*—Patient B, aet 12, was admitted on 23-3-37. History of fever for 3 days. Patient was put on Ax from 25-3-37 in ·75 grs. doses thrice a day. The effect of the treatment is shown in Chart V. On 23-3-37, B.T. trophozoites were present in the blood; on 28-3-37, no malarial parasites were found; on 23-3-37, spleen was moderately hard and 2″ below costal margin; on 1-4-37, spleen was felt just below costal margin.

*No. VI.*—Patient R, aet 32, was admitted on 24-3-37. History of fever for 8 days. Patient was put on Ax from 25-3-37 in 1½ grs. doses thrice a day. The effect of the treatment is shown in Chart VI. On 24-3-37, M.T. rings were present in the blood; on 30-3-37, only crescents were found; on 24-3-37, spleen was 1½" below costal margin; on 9-4-37, spleen was just felt below costal margin.

*No. VII.*—Patient B, aet 30, was admitted on 13-9-37. History of fever for 28 days. Patient was put on Ax from 16-9-37 in 2½ grs. doses twice a day. The effect of treatment is shown in Chart VII. On 13-9-37, M.T. trophozoites were present in blood; on 19-9-37, no malarial parasites were found; on 13-9-37, spleen was 1" below costal margin; on 27-9-37, spleen was not palpable below costal margin.

*No. VIII.*—Patient R, aet 30, was admitted on 20-9-37. History of fever for 4 days. Patient was put on Ax from 23-9-37 in 1½ grs. doses twice a day. The effect of the treatment is shown in Chart VIII. On 37-20-9, plenty of M.T. rings were present in the blood; on 25-9-37, only crescents were found; on 20-9-37, spleen was 1" below costal margin; on 25-9-37, spleen was not palpable below costal margin.

*No. IX.*—Patient M, aet 15, was admitted on 7-10-37. History of fever for 5 days. Patient was put on Ax from 10-10-37 in 1½ grs. doses twice a day. The effect of the treatment is shown in Chart IX. On 8-10-37, B.T. trophozoites were present in blood; on 12-10-37, no malarial parasites were found; on 7-10-37, spleen was 1½" below costal margin; on 15-10-37, spleen was ½" below costal margin.

*No. X.*—Patient G, aet 20, was admitted on 6-10-37. History of fever for 6 days. Patient was put on Ax from 8-10-37 in 1½ grs. doses twice a day. The effect of the treatment is shown in Chart X. On 6-10-37, M.T. rings were present in blood; on 10-10-37, only crescents were found; on 6-10-37, spleen was 1½" below costal margin; on 15-10-37, spleen was ½" below costal margin.

*No. XI.*—Patient H, aet 20, was admitted on 7-10-37. History of fever for 6 days. Patient was put on Ax from 8-10-37 in 1½ grs. doses twice a day. The effect of the treatment is shown in Chart XI. On 7-10-37, M.T. rings were present in the blood; on 13-10-37, only a few crescents were found; on 7-10-37, spleen was 1 finger below the costal margin; on 13-10-37, spleen was not palpable below costal margin.

Chart No. I.

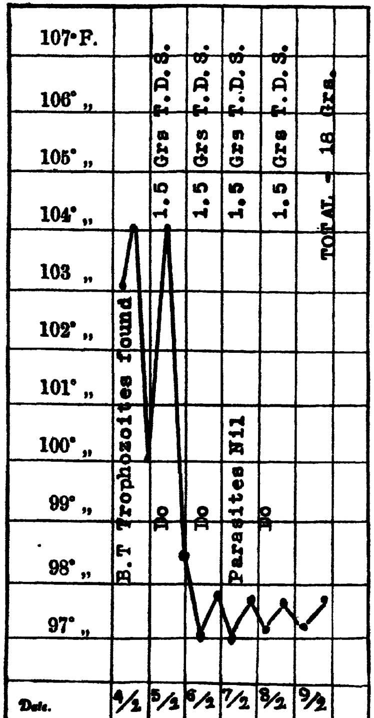



Chart No. II.

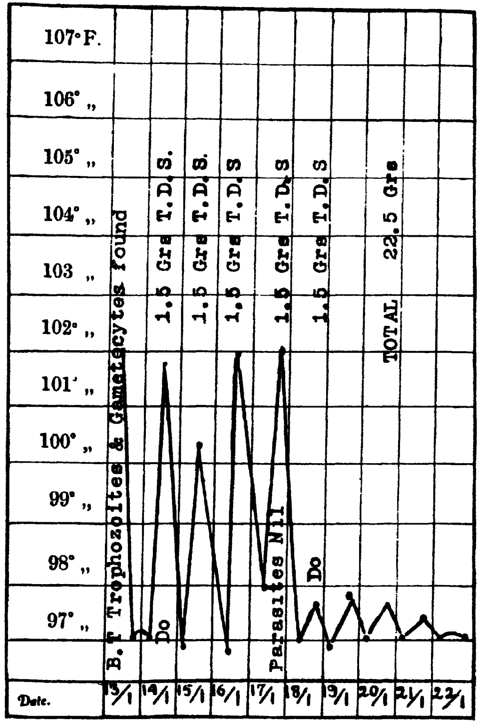



Chart No. III.

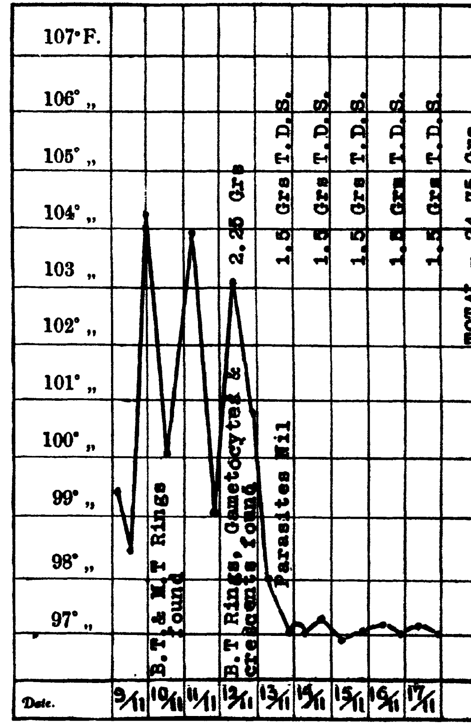


CHART No. IV.

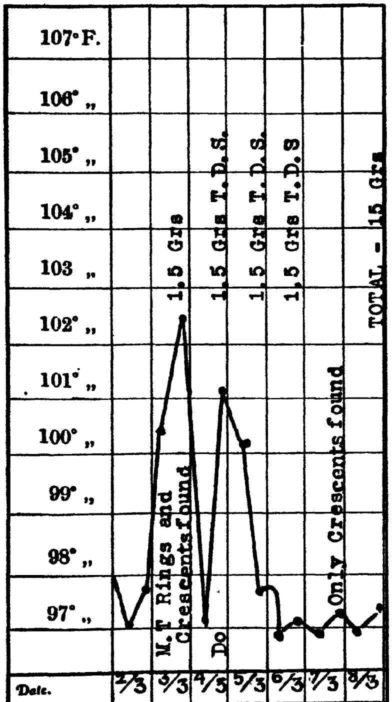



CHART No. V.

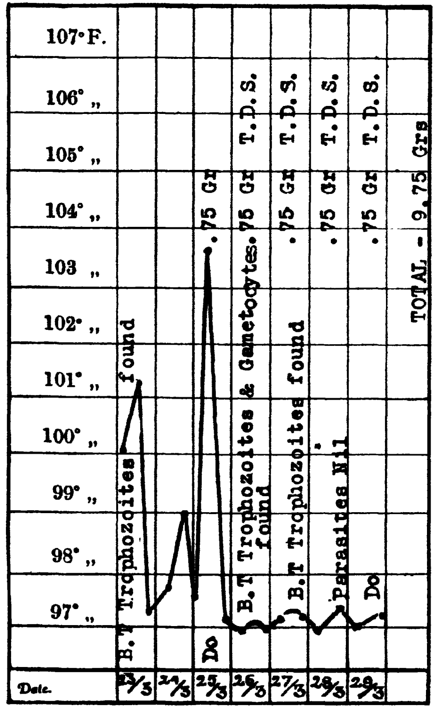



CHART No. VI.

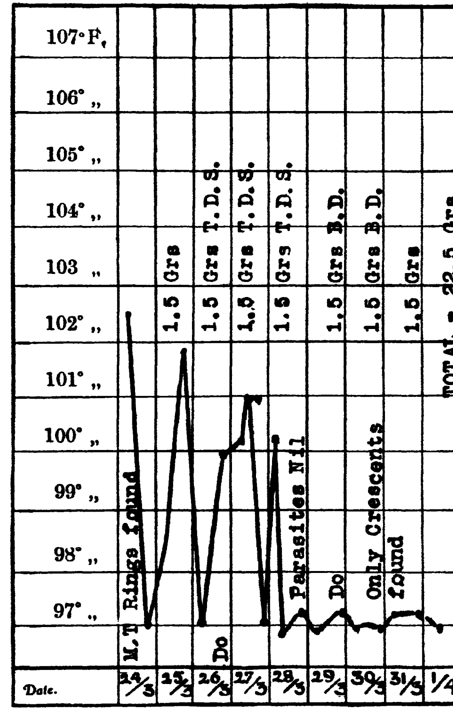
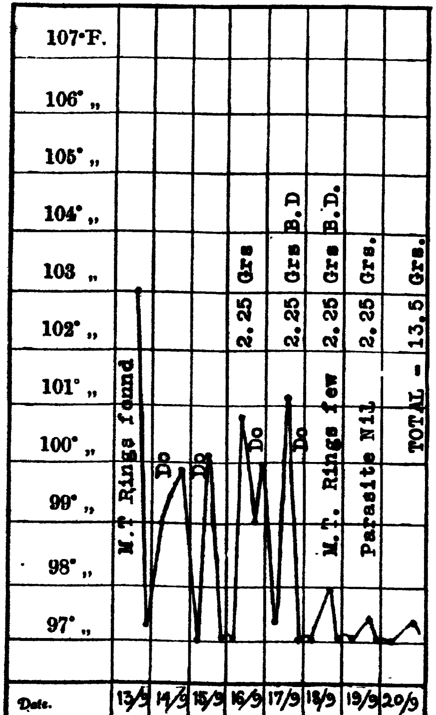


Chart No. VII.

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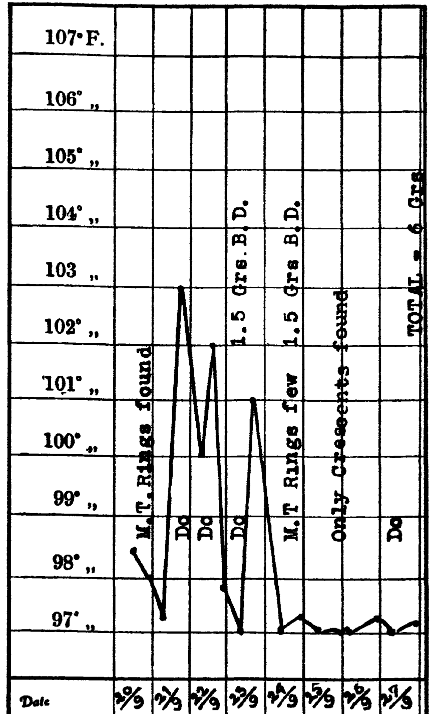



Chart No. IX.

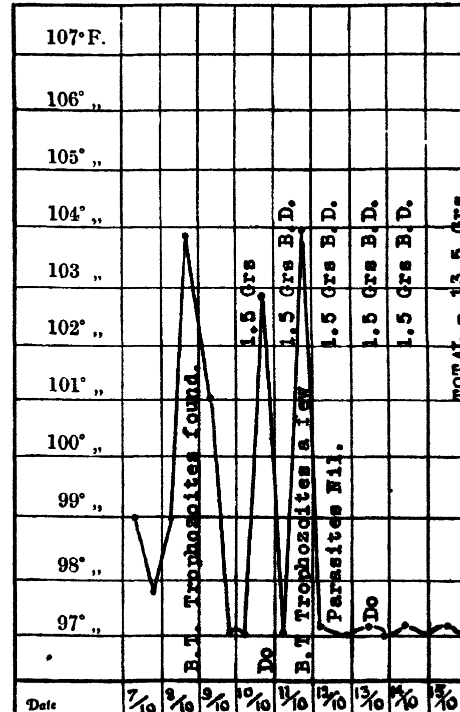


Chart No. XI.

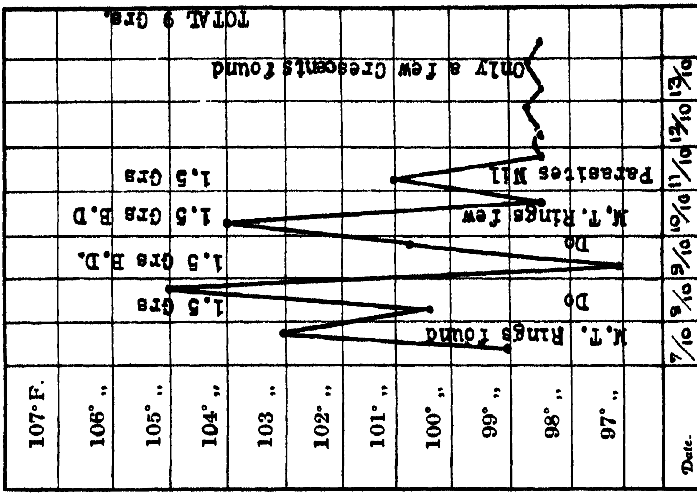
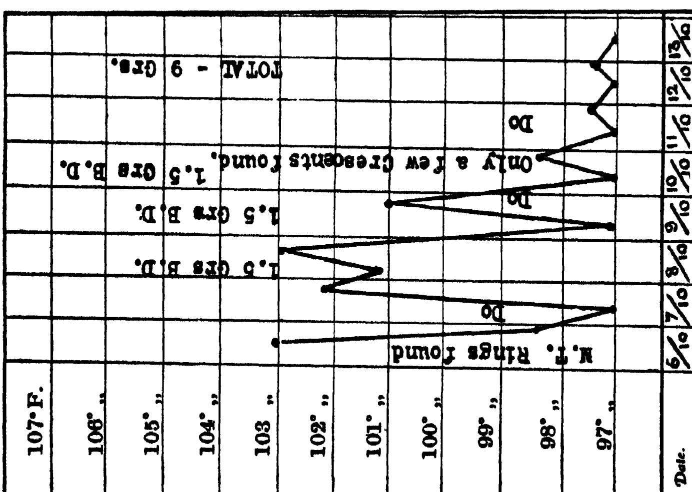



Chart No. X.



### *Action of Acridin X in Monkey Malaria.*

The action of this drug in monkey malaria has been studied by Shortt and K. P. Menon. The following notes are taken from the paper of these authors entitled '*On Acridin X in the treatment of monkey malaria*' (Indian Science Congress Abstracts Section of Medical Research, 1938) :—

> 'A series of experiments on Acridin X in the treatment of monkey malaria was carried out on monkeys infected with *Plasmodium knowlesi* comparing the action of the drug with that of atebrin for injection. The effect in sterilizing the peripheral blood, the cure rate, and relapse rate of the two drugs were compared. The results of the experiments showed the two drugs to be identical in their action on P. knowlesi.'

Up to now the synthetic antimalarials are mostly derived for the quinoline or acridine nucleus. As is well known, it was originally considered that the piperidine nucleus in quinine was responsible for the antimalarial properties of the latter. A few piperidine compounds have been synthesized under the author's direction, but so far they have been found to have no antimalarial properties. It may be stated, *en passant*, that one of them, namely, *piperidino-acetyl-8-amino-6-methoxy-quinoline dihydrochloride*, failed to show any antimalarial properties.

The synthesis of organic antimalarials has opened up a new vista in the treatment of malaria and will no doubt play an important point in the future campaign against the disease and its conquest.

The discoveries of effective antimalarials and leishmanocides rank among the highest triumphs of tropical medicine. Until recently, they were slumbering, like sleeping beauties, in some unfrequent corners and they now appear to have awakened as fairy gifts which synthetic chemistry bestows from time to time upon mankind.

Ladies and gentlemen, from what I have stated in my address, it will be seen that dreadful diseases like malaria and kala-azar will be conquered one day in India and thus a new chapter will be added to 'The Endless Quest'. If along with this conquest there is in India 'a proper balance between labour-saving devices and industry-increasing discoveries', and if her people 'will but decide to put in play the methods', which science today has provided for sufficient supply of food and clothing and shelter, then the health and economic problems of India, with her endless natural resources, will be solved to a great extent ; then much of her unrest and unemployment will cease and she will have the opportunity of being richer, happier, healthier and freer than ever before.

# SECTION OF VETERINARY RESEARCH

*President* :—Col. Sir Arthur Olver, C.B., C.M.G., F.R.C.V.S., F.N.I.

# *Presidential Address*

## DEVELOPMENT OF VETERINARY WORK IN INDIA

Before proceeding with my address I must introduce our distinguished guest, Sir Fredrick Hobday, whose life-long devotion to the interest of the veterinary profession and numerous contributions to Veterinary Science are known to all of you.

To mention but one or two of Sir Fredrick's best known achievements in the field of Veterinary Science I would instance his development of the ventricle operation on horses, for the alleviation of roaring, and his research on the Anæsthesis of domesticated animals. His results were at that time a striking advance on anything which had been done before and have been of the utmost benefit particularly in canine and feline surgery.

After several years, as a Professor at the London College, Hobday left it and took up veterinary practice; but in the early days of the Great War he joined up, with characteristic enthusiasm and devotion to duty, and I was fortunate enough to have personal experience of the very valuable service which he rendered with the expeditionary force in France. Subsequently he served with distinction on the Italian Front as well and received recognition on both in the form of foreign decorations.

But his greatest achievement of all, for the benefit of the veterinary profession, has been the rebuilding of the Royal Veterinary College, which when he took it over was so dilapidated that a number of the buildings had to be propped up and the accommodation available at this, the premier veterinary college of the United Kingdom, was scandalously inadequate compared with the provision made in more far-seeing countries.

To obtain the very large sum of money which was needed, amounting with the Government contribution to a ¼ million pounds sterling, no possible source could be left untapped and in addition to his duties as Principal, Hobday devoted himself with amazing energy to securing this great sum previously almost unheard of in relation to the poorly paid veterinary profession. That he succeeded, in face of a great deal of scepticism and apathy, the magnificent college equipped with every modern convenience for veterinary work of all kinds, which has recently been opened

by Their Majesties the King and Queen, bears witness and will remain a standing memorial of the great service thereby rendered to veterinary education and the veterinary profession. Hobday realized that no profession can take its proper place without proper training and made up his mind from the outset that England should have the most commodious and best equipped college in the world and we can only marvel at the success which attended his labours.

This being the Jubilee meeting of the Indian Science Congress Association, rather than address you on a scientific subject, I will try to give a brief account of the development of veterinary work in India.

As long ago as 1788 Joseph Earl published in Calcutta an English translation of a Sanskrit work on the diseases of horses, entitled Saluter and Farrier and subsequently J. P. Pigget, a Lieut. of Indian Cavalry, published, also in Calcutta, a treatise on the horses of India in which he suggested that Government should take up horse-breeding. But neither of these seems to have had any veterinary training and the need for veterinary assistance in India seems not to have been understood until after 1774 when the East India Company started horse-breeding studs. It is recorded that their operations up to that time had proved a failure and that disease was rampant. The actual record of veterinary work in this country seems to have commenced in 1799 when Veterinary Surgeons, trained at the London Veterinary College, were drafted to India for the organization of cattle and camel breeding and the establishment of studs for the breeding of cavalry horses.

William Moorcroft, who came to India in 1808, was one of these early veterinarians and appears to have been a man of outstanding ability, personality and energy. After receiving medical training at the Liverpool Infirmary, and while still a pupil he was invited to investigate an outbreak of cattle plague and his success in this matter led him to take up veterinary science as a permanent calling. With this object in view he joined the veterinary school at Lyons, in March 1790, and after qualification returned to England in 1792 to take up veterinary practice in London. Sixteen years later, in order that he might take up an appointment in India which had been offered him, he gave up the extensive veterinary practice which he had built up in the meantime and, in 1808, was appointed, by the East India Company, Superintendent of their Bengal stud which was located at Pusa in North Bihar. It is recorded that by improved management he reduced losses by 90 per cent and that among other things he was responsible for oats being cultivated in India for the first time.

While holding this appointment Moorcroft, with a view to improving the breed of Remounts for India, carried out two extensive journeys in Central Asia and during the course of the

second appears to have been murdered. In Bokhara he had obtained the horses he was in search of, both mares and sires, and had started on his return journey to India, but he unfortunately turned aside to visit Balkh, a place said to contain the finest horses in the world and was never seen again. His property was plundered and his copious Journals were lost for years.

The main object of his journey was therefore not achieved but his journals afterwards proved a mine of information on a great variety of subjects and it is evident that Moorcroft did a great deal to establish the value of veterinary knowledge in horse-breeding and in the care and management of breeding studs. Among other things he published a comprehensive pamphlet of directions for the use of Company officers, and was the first to introduce machine-made shoes. He also wrote a small book on shoeing and appears to have been quite familiar with the symptoms and progress of such conditions as Navicular disease.

Indeed there is a record in the Calcutta Journal of March 1819, that he performed the operation of neurectomy for that disease. After trying the arteries to reduce the inflammation, without benefit, he divided the nerves and removed a portion with the result that the lameness disappeared. There is also in existence a letter of Moorcroft's in which he describes the clinical feature of Glanders and how to stay infection. In this letter he pointed out that Strangles might be confused with Glanders, and drew attention to the great frequency of generalized Strangles in Asia than in Europe. He knew that Farcy and Glanders were due to an identical poison and that the Glanders discharge, when dried, retains its virulence for months. He considered Bursati to be in all probability infectious and stated that flies might carry infection.

In the Journal kept by Moorcroft, in which the observations made during his travels were recorded, various matters of veterinary interest were found. Amongst others he warned the Government of India against a fatal disease met with in the Punjab which, from the postmortem appearances described by him, has since been identified as Anthrax. He also mentioned a plant growing in Western Tibet, known as Prangos, which was believed to prevent or cure fluke disease in sheep and stated that in Afghanistan a course of green feeding with 'Shufteed' was given to get rid of parasites. His interests were so wide that among other things he sent home a mass of valuable information, on a variety of matters connected with agriculture, and he is credited with having placed the Kashmir shawl industry on a sound footing. He described a breed of mountain sheep with wonderful wool and gave an account of a new species of the genus *Equus*; which was neither horse, ass, nor mule and which he thought might have been the Onager of Pliny. He also

described the method of training horses which was adopted in Central Asia prior to a raid. The system consisted in a gradual increase of work with no bulky food; the diet being mainly barley with water given once a day only. When the horse was fit, it was considered that its fæces put in a clean dry cloth and squeezed should not leave a stain. Thus Moorcroft must have been far ahead of his time in many ways and it is recorded that he was a short, slight, quick-tempered man of high intelligence and wide interests. His tomb is in Lahore.

The earliest available official reference to veterinary work in India appears to be a general order of the Bengal Army, dated 8th of April 1793, in which it is stated that upon the appearance of a supposed infectious disease among horses, the affected would be removed from the Cantonment and the matter reported to the Officer Commanding the Station, 'who will order the animals to be inspected by persons who may be judged capable of distinguishing the disorders of horses'. At that time there was not a single qualified veterinarian in India and only two in England: Sainbel and Moorcroft. In 1799, five veterinary officers, trained at the Veterinary College, London, proceeded to India, but two of these were soon invalided home and little is known of their work. It appears that these veterinary officers were attached to British Regiments serving in India.

From 1826, after Moorcroft's death had been confirmed, until 1832, the management of horse-breeding establishments was again under the control of Infantry and Cavalry officers but in 1832, in consequence of terrible losses from disease, the East India Company insisted upon Veterinary Surgeons forming part of the staff of the various depots and J. T. Hodgson appears to have been one of these and a man of considerable influence. From the Government horse-breeding stud at Hissar, in the Punjab, he was appointed to the Governor-General's Body-Guard at Calcutta, in 1821, and was directed to train Assistant Apothecaries—half-caste Indians—as Veterinary Surgeons for the troops of the Bengal Army. When qualified, these men were to be appointed Sub-Assistant Veterinary Surgeons with the pay and allowances of an Apothecary. But in 1822, Hodgson warned the Bengal authorities that their scheme would not work, so the project came to nothing and in 1823 only three Sub-Assistant Veterinary Surgeons were borne on the establishment of the Army. In August of that year, Hodgson submitted to the Government of India a scheme for the creation of an organized veterinary service. His proposals were that the East India Company should provide a professor at the London College to deliver a course of lectures to candidates for the Indian Service on the breeding, rearing, management and diseases of horses, cattle and camels and on shoeing, so that prior to proceeding to India, veterinarians should have expert knowledge of these matters. To these lectures the Company's civil, military and

medical servants were to be admitted, should they desire to attend, and Hodgson considered this preferable to the arrangement made by Coleman to give lectures on veterinary matters to cadets at Woolwich. In regard to the organization of veterinary services in India, Hodgson proposed an officer on the general staff of the Army in India, as principal Veterinary Surgeon; one veterinary officer each to the forces in the Presidencies of Bengal, Madras and Bombay and an administrative officer to each Division, in addition to executive officers for Brigades of Horse Artillery, Regiments, Cavalry, breeding studs and other Departments of the Army provided with animals. He made provision for sickness and deaths, by having a certain number of supernumerary officers available in India, and drew up tables of pay and allowances; rules regarding promotion, leave and pensions, and formulated a set of veterinary regulations, but his proposals appear never to have been acted upon.

In 1827, twelve Veterinary Surgeons came out to India and in 1828 a further 13, while subsequently, veterinarians were supplied as casualties occurred. The establishment in the three Presidencies in 1833 was 31. Recruits appear to have been selected by Mr. John Field of the 2nd Life Guards. They were intended for the care of army animals but the Veterinary Department of India remained without an official head or a single administrative officer for forty years. Thus the early veterinary work done in India appears to have been done by veterinary officers of British and Indian Cavalry Regiments and much valuable information was undoubtedly obtained regarding the diseases of domesticated animals in this country. For example in 1881, Griffith Evans, of the Army Veterinary Department, for the first time demonstrated a large flagellated organism—now known as *Trypanosoma evansi*—in the blood of horses and camels affected with Surra, a previously little understood but well-known fatal disease of all classes of domesticated animals in India. Evans was born in Wales in 1835 and entered the Army Veterinary Service in 1860. He proceeded to Canada in 1861, with the Royal Artillery and while at Montreal graduated in medicine at the McGill University. His scientific enthusiasm was widely known and was referred to by Sir William Osler, Regius Professor of Medicine at Oxford, but Evans' report of his discovery was referred to the Sanitary Commission to the Government of India and was not accepted, while his findings were derided in certain quarters. They have, however, since proved to be an epoch-making advance in the knowledge of protozoan disease and have been of immense benefit to the human race as well as to their livestock.

The next important event in the advance of veterinary work in India was the recommendation by Hallen of the formation of an Indian Civil Veterinary Department with schools for the training of students. Hallen entered the service of the East

India Company in 1850, joining the Bombay Veterinary Service and, in 1862, became Inspecting Veterinary Surgeon of the Bombay Army. He organized the veterinary service of that force and established an Army Veterinary School at Poona. In 1863 he was made Superintendent of the Stud Department of Bombay and from 1863 to 1868 was head of the Veterinary Service in the Abyssinian War. In 1869 his services were asked for by the Government of India, in connection with Cattle Plague and he became President of the Commission which sat until 1872. From 1872 to 1876 he was one of the Commissioners charged with the breaking up of the old Indian studs and he organized the horse-breeding operations of India, of which he was Superintendent. Finally, in 1892 he became Inspector-General of the Civil Veterinary Department of India. He was awarded the C.I.E.

The next personality of outstanding influence on veterinary developments in India was Col. Pease, who by his energy and ability raised the Lahore School from very humble beginnings to an outstanding position. Among other activities, he translated textbooks into Urdu, for the use of students, and lectured in that language. He conceived the formation of an Imperial Bacteriological Laboratory; originated and edited the Journal of Tropical Veterinary Science—with other enthusiasts among whom the names of J. H. Steel and F. Smith (afterwards Maj. Genl. Sir F. Smith) should be mentioned—and appears to have been the first to diagnose the existence of Dourine in India. He also did valuable work on Surra and, while actively engaged in the cattle survey of India, published a very valuable series of books on the breeds of Indian cattle.

The first veterinary school opened in India appears to have been that at Babugarh which was opened in 1874, a similar one being established about the same time at Rangoon. The Babugarh school was afterwards transferred to Lahore and formed the nucleus of the present college. Subsequently veterinary colleges were established at Bombay, Calcutta, Madras and at Ajmer (Merwara) but this last was afterwards closed and the staff merged in that of the Lahore Veterinary College. Later a Government Veterinary College was established at Patna and it is worthy of note that the colleges at Calcutta and Bombay were established as a result of private donations of large sums of money; in the first case by a wealthy zamindar and in the second by a well-known Parsi philanthropist.

In 1881 the Government of India offered a prize worth Rs.200 for the best original paper on the horse disease commonly known as Kumari or Paraplegia and in 1883, with a view to encouraging the study of Veterinary Science, the Governor of Bengal offered two prizes, one of £50 and the other of £20; open to Army holders of agricultural scholarships from Bengal, who had studied at the Royal Agricultural College, Cirencester.

Thus the value of veterinary work gradually became established but even today the position of disease control in India is peculiar in that there are no veterinary practitioners, except a few in Calcutta and other big cities, and stock-owners are almost entirely dependent on Government veterinary services for veterinary aid. It is therefore incumbent upon Governments to organize and maintain suitable provincial veterinary services ; for the control of contagious disease and to provide veterinary aid and assistance in the proper care and management of livestock. In the early days, these services were mostly under the Director of Land Records and at that time there were no veterinary colleges in India. The obvious step for the advancement of Veterinary Science was therefore to establish suitable colleges or schools for the training of veterinarians in India and when graduates became available, provincial veterinary services were gradually organized ; by officers transferred from the Army Veterinary Department to take charge of the newly formed Civil Veterinary Departments. Veterinary hospitals and dispensaries were opened at suitable centres and the work of the Departments has gradually been developed and extended as more graduates have become available.

In most provinces, superior veterinary services were formed, officered by veterinarians with the M.R.C.V.S. or equivalent qualification and, in addition, subordinate services officered by graduates of Indian veterinary colleges.

An Imperial Veterinary Service was also formed but recruitment to this service ceased in 1924 and the number of fully qualified veterinarians in India remains far too small for the bare requirements of such a huge country. For example, the Royal Commission on Agriculture in India recommended 300 officers and 6,000 subordinate staff for British India but in 1936-37 the strength was only 109 and 1,646 respectively. Various proposals have been put forward for the establishment of an All-India Veterinary College, to train up to the M.R.C.V.S. standard, and the matter is now being dealt with. But as no such course was available in the country, the Government of India and Provincial Governments decided, in 1920, to give a limited number of scholarships to enable students to take the M.R.C.V.S. qualification in the United Kingdom. In addition a number of students have obtained this qualification at their own expense.

The scope for development of veterinary work in India is however immense, not only in the control and treatment of contagious and enzootic disease, which is rife, but also in such animal husbandry matters as systematic control of breeding operations, and inoculation of improved stock against diseases combined with organized castration, at a suitable age, of inferior males not required as sires.

Owing to the general lack of wealthy land-owners who take a genuine interest in livestock improvement this work is of the

greatest importance and recently the Government of India has recommended that all animal husbandry work should be in the hands of Provincial and State Animal Husbandry Departments, based on the existing Provincial Veterinary Departments. At present this work is partly in the hands of Veterinary Departments and partly Agricultural Departments but it is clearly essential that veterinary graduates from Indian colleges should in any case be thoroughly grounded in animal husbandry subjects; particularly as there hardly exists in India an educated class of scientific stock breeders from which young men with hereditary knowledge and interest in livestock could be drawn for the control of breeding operations. Indians who have received veterinary training have already proved their superior value in such work and with a view to increasing existing facilities, particularly for training in animal husbandry, it has recently been recommended that a dairy should be maintained at every veterinary college in India and that the I.D.D. course should be open to veterinary graduates, after a reduced course of study in addition to what is given in their graduate course.

One of the most important steps ever taken for the development of veterinary work in India was the appointment in 1891 of an Imperial Bacteriologist, whose headquarters were in the first instance at Poona. After two years, it was decided to instal this officer at a Veterinary Research Laboratory at Muktesar, in the Kumaon Hills, 'for the investigation of diseases of domesticated animals in all provinces in India'. The first Imperial Bacteriologist was Lingard, a medical man, who among other things discovered the specific affinity of arsenic for the parasite of Surra: a discovery which has led to results of the greatest importance to the human race. From the day of its establishment in the Kumaon Hills, where it was free to carry on systematic research in animal diseases of all kinds, the Muktesar Institute has built up a world reputation and has done an immense amount of work of the greatest value to Indian stock owners. The advances made by Veterinary Science in India during the past 25 years have been fully dealt with by Mr. Ware in a paper specially prepared for this meeting and I will not attempt to discuss them in detail but there are a few general remarks in regard to the control and treatment of disease in this country which I would like to make. The most important advance from the point of view of owners of livestock has undoubtedly been the great step forward which has been made in the control of Rinderpest due to the general adoption of a system of vaccination with goat virus. This method has been evolved as a result of the continuous research and investigation, which has been carried on at Muktesar for many years, into all matters relating to Rinderpest control. In the course of this work Dr. J. T. Edwards produced a goat virus of fixed and reduced virulence for the ox and from this beginning a method of vacci-

nation has been evolved there, which has proved highly successful and economical in controlling outbreaks of Rinderpest among plains cattle, without the use of anti-Rinderpest serum. This discovery has made it possible to control outbreaks at fractional cost, compared with the cost of the serum simultaneous or serum alone methods, and at the same time to confer lasting immunity which, so far, has proved to be solid one, for as long as it has been possible to test it, i.e. up to more than 3 years. For the poor cultivator of India, whose very life depends on his cattle, this is an immense boon and the fact of Cattle Plague being so comparatively easily and cheaply controllable has enabled Provincial Veterinary Departments to devote more attention to other fatal diseases such as Hæmorrhagic Septicaemia, Black quarter and Anthrax. These still take a heavy toll of the cattle of India but are now better under control by means of biological products, evolved for the most part in other countries, and during the past 5 or 6 years great advance has been made in the treatment of Surra as a result of research at Muktesar and systematic investigation carried out in the Punjab and other provinces. Great advance has also been made in the study and control of various forms of Schistosomiasis, of which nasal granuloma is an important and often fatal manifestation, over large areas particularly in S. India, and in the study of lesions of the skin and subcutaneous tissue due to larval forms of Filaria. Progress has also been made in the study and treatment of diseases due to the great variety of Piroplasmal organisms which are of great economic importance to India. The study of the protozoa pathogenic to livestock in India is however an immense subject, the fringe of which has hardly been touched, and far more requires to be done to obtain precise information regarding these organisms and the helminths by which livestock of all kinds are parasitized to an enormous extent throughout India.

The systematic disease investigation now carried on in all provinces and some of the large Indian States has moreover brought to light a number of disease conditions, due to malnutrition and other causes which were previously not understood, and has enabled steady advance to be made in the study and control of a great variety of diseases of stock of all kinds.

But the field for scientific veterinary work in India is immense and the fully trained workers are few. Meanwhile the poor ryot has to suffer continuous and heavy loss from a great number of causes which, with more and better trained staff and more adequate provision for combined veterinary and animal husbandry activities, could easily be brought under better control.

Some research is carried on at Indian veterinary colleges, notably at Lahore and Madras, and during the past five years provision has been made by the Imperial Council of Agricultural Research for systematic investigation of the disease of livestock,

in provinces and States throughout India, by the provision of veterinary investigation officers paid by the Imperial Council of Agricultural Research. Though paid out of funds provided by the Imperial Council of Agricultural Research these officers are under the direct control of the Director of Veterinary Services of the province or State concerned and work in collaboration with the Muktesar Research Institute, or a veterinary college where suitable facilities for research exist.

There are in all five veterinary colleges in India, the longest established being the Punjab Veterinary College at Lahore which was originally founded as an elementary school by Col. J. H. B. Hallen at the Remount Depot, Babugarh. This Remount Depot was, however, abolished soon afterwards and in 1882 the veterinary school was transferred to Lahore with Col. Kettlewell as the first Principal. In spite of its humble beginnings and very inadequate accommodation and equipment, this school has continued to make steady progress and has established its great value to livestock owners. The successive Principals of this college have been Col. G. Kettlewell (1882–90), Col. J. Nunn (1890–97), Col. H. T. Pease (1897–1907 and 1912–19), Col. A. Smith (1907–12), Col. G. K. Walker (1919–26) and Mr. W. Taylor who at present holds this post.

The course of instruction was originally given in the vernacular and was of two years' duration but, in 1900, the period of the course was raised to three years and the name of the institution was changed to 'The Punjab Veterinary College'. In 1905, the veterinary school which had previously been established at Ajmer was abolished and its teaching staff was absorbed by the Punjab Veterinary College while in 1919 under Col. Pease new and commodious buildings and accommodation were provided which made the Lahore College an exceptionally well-equipped veterinary college, for training in all branches of Veterinary Science. At that time the course was still a three-year one but in 1919, during Col. Walker's principalship, four-year course in English was instituted and the Intermediate Examination of the Punjab University or equivalent test was made the educational standard for admission to the college.

In August 1886, a veterinary college was opened at Bombay in the S.P.C.A. Buildings which, in 1883, had been presented by Bai Sakarbai Dinshaw Petit, a well-known Parsee philanthropist of Bombay city. The hospital buildings were handed over to Government and some additional buildings required for the use of the college were built afterwards.

The course of study at this college has been a three-year course in English since its foundation but the standard has varied considerably. J. H. Steel, the first Principal, originally aimed at obtaining recognition by the Royal College of Veterinary Surgeons and, with this object in view, drew up a syllabus for the advanced course which was brought into force in 1890. But,

Steel very unfortunately died, in January 1891, and the syllabus drawn up by him, being considered too advanced, was modified and simplified. In 1900, a Conference of Principals of various Indian veterinary colleges and schools was held at Ambala and, as a result of this Conference, the written examinations at the Bombay Veterinary College were discontinued and the course was simplified and made uniform with the courses at that time given at the Bengal and Lahore colleges, an oral test being the only test then applied. A simplified curriculum thus became the basis of all veterinary education in India and at first non-Matriculate students were admitted, but later the educational standard was raised to Matriculation at all veterinary colleges. This standard is still the standard of admission to the Bombay Veterinary College and the course is still a three-year one, in English. The Principals of this college from its inception have been Mr. J. H. Steel (1886–1891), Lt.-Col. James Brodie Mills (1892–1908), Major Frank Josler (1909–1910), Mr. K. Hewlett (1911–1930) and Mr. V. R. Phadke who at present holds this post.

The establishment of a veterinary college in Calcutta was first recommended by the Cattle Plague Commissioners, on the completion of their duties in 1871, and in the interim repeated proposals were made by the Inspecting Veterinary Surgeon, J. H. B. Hallen, to provide such a college. No action was, however, taken until 1891, when Babu Sheo Baksh Bagla generously gave Rs.30,000 to Government in aid of the project and offered 7¼ bighas of land for the site. Sir Dinshaw Monochjee Petit also promised a donation of Rs.25,000 for the establishment of the hospital. The school was opened in January 1894 and was subsequently raised to the status of a college in 1898. The first Principal was Col. F. Raymond (1898–1912) followed by Col. A. Smith (1913–1920) and Mr. A. D. MacGregor, the present Principal. The course of training at this college is a three-year course in English.

As long ago as 1882, veterinary courses appear to have been given in Madras, at the School of Agriculture at Saidapet, by Veterinary Surgeon—James Mills, A.V.D. The curriculum at that time embraced among other subjects, veterinary medicine and surgery and the course extended to three years. The present Madras College was opened in 1904 and has been extended from time to time by the provision of increased laboratory accommodation and facilities for carrying on research and the manufacture of biological products ; while recently a small dairy has been established in connection with this college, with a view to providing increased facilities for the instruction of students in the care and management of animals in health.

The course is a three-year one in English and recently the college has become affiliated to the Madras University by which, after a short course of extra instruction, the degree of B.Sc. (Veterinary) is granted to successful candidates. The Principals

of this college have been Major W. D. Gunn (1904–1908), Mr. D. A. D. Aitchison (1909–1925), Mr. F. Ware (1925–1927), Mr. P. T. Saunders (1927–30), and Mr. T. J. Hurley who at present holds this post.

In 1930 a veterinary college was opened at Patna. The establishment of this college was the work of Mr. D. Quinlan, the then D.V.S., Bihar and Orissa, and it is fortunate that he had the vision to establish an extensive farm at which cattle breeding and dairying can be carried on and made use of for the grounding of veterinary students in the care and management of cattle; which is so essential to the training of veterinary students in India. The course is a three-year one in English and the minimum educational qualification laid down for admission to the college is Matriculation. The Principal of this college since its institution has been Mr. R. T. Davis.

Thus there are five veterinary colleges still in existence in India, but the staff and facilities provided for veterinary training in this huge country are still very inadequate, even for training up to the comparatively low standards which are accepted as sufficient for veterinary graduation.

The provision of a central veterinary college, to provide training up to the M.R.C.V.S. standard and in research, in conjunction with the Veterinary Research Institutes of Izatnagar and Muktesar, is being taken up by the Government of India but more fully qualified staff and better facilities for research and animal husbandry training are urgently needed at most of the existing colleges; to enable them to train up to modern standards and to carry out such diagnostic work and research as can suitably be undertaken at such colleges.

This has become all the more necessary since the provision by the Imperial Council of Agricultural Research of Veterinary Investigating Staff, in each major province and certain States, which it is now proposed to extend and develop for the systematic investigation of disease problems all over the country which is so urgently needed. This investigation work has increased the demand for co-ordinated veterinary research.

The field for such work is unlimited and up to the present almost untouched but, for such work, high standards of education and veterinary training are needed and I appeal to Indian veterinary institutions of all kinds to aim constantly at producing veterinarians fully equipped for such work and able to take the predominant place in animal husbandry work for which their training under Indian conditions and daily experience should form the best background. The low standards of education and training which are now commonly accepted for Indian veterinary graduates will never provide the highly trained veterinary services which are essential for the proper study and control of disease and for systematic improvement of livestock in this sub-continent and if the veterinary profession aspires to take

its proper place and to justify higher scales of pay it will have to insist on raising its standards, at least as regards selected students, to the levels which have now been adopted in all progressive countries. Low standard of education and training can only mean low status and low scales of pay.

# SECTION OF PHYSIOLOGY

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## *Presidential Address*

## THE PHYSIOLOGY OF THE INDIVIDUAL IN THE TROPICS

### INTRODUCTION

I consider it my duty first of all to thank you for the great honour you have done me in asking me to be the President of the Section of Physiology during this, the Jubilee Session of the Indian Science Congress. When the invitation was first extended to me, I had considerable hesitation in accepting it. As my labours have been principally confined to the domains of pharmacology and tropical medicine, my first reaction was to consider whether I would be justified in assuming the responsibilities of guiding the deliberations of the group of scientists who have assembled here to-day. On further consideration I persuaded myself to accept the honour, for physiology after all is the science of function, whether it is studied in broad outlines as dealing with the mechanism of action or as the physico-chemical mechanisms leading up to this action. Disease means a lack of integration or balance of the normal body processes (disintegration) or an unusual functioning of tissues (dysfunction) which may be the result of accident, hereditary weakness or parasitic organisms. It is not correct to designate it as disordered function (malfunction) as is sometimes done; the unusual functioning is physiological and perhaps the best for the organism under unusual conditions. Medicine aims at prevention or cure of 'disease' and it is, therefore, nothing more than trained and organised application of the principles of physiology. Pharmacology, the science dealing with the action and uses of drugs on tissues, is inseparable from physiology. It is, in fact, the climax of physiology and pathology. Both pharmacology and medicine therefore are not far removed from physiology and if one who has been engaged in the field of pharmacology and tropical medicine for about a quarter of a century accepts such an honour and assumes the rôle of a physiologist, he may be pardoned.

'Normal' individual a relative term.

Though physiology in its widest sense signifies the study of the phenomena presented by all living organisms, its chief interest is centred round the body of man. It should therefore be the objective of human physiology to study the so-called 'normal' human individual, since it provides an essential base line for the study of disease. Unfortunately, however, in this particular branch, 'physiology' in spite of all its developments has made but little progress in recent years. The definition of 'normal', and the criteria of what constitutes the normal, are still open question. There has been a tendency among physiologists to lay stress on individual organs and tissues,—'on single bricks' composing the edifice —and not on the individual as a whole. As the human individual cannot exist uninfluenced by his external environment and as the environment is variable, the question of normality of the individual becomes relative, and has to be studied under the varying conditions of the altered and continually altering environments to which the individual must necessarily be subjected in different parts of the globe. In choosing the subject of '*The physiology of the Individual in the Tropics*', I had two objects in view. In the first place, I was anxious to select a subject which would be of interest to physiologists as well as to the medical profession in India; in the second place, I chose it as a subject which is of fundamental importance, but which has suffered from comparative neglect in modern medical thought.

## THE INDIVIDUAL AND HIS ENVIRONMENT

Historical.

The study of the individual in relation to his environment has recently engaged the attention of many a physiologist and clinician though the problem is by no means a new one. In the earliest days of medicine in India centuries before the Christian era, the Hindu physician *Charaka* drew attention to the effects of different 'airs' and places on mankind. He prescribed special diets for particular seasons of the year, recommending one type of food for the summer and another for the winter. In the early dawn of Greek medicine Hippocrates recognised not only the significance of a 'change of winds' but also its physiological implications. After considering the effects on the embryo and the adult, he concluded that the races of mankind and types of animals were altered, as a result of the environment—and in this the 'airs, waters, and places' played a part. The Hippocratic recognition of the association between meteorological conditions (airs) and disease came down through the middle ages and practically every writer on medicine and physiology from the 17th to the 19th century stressed in different ways

Discovery of bacteriology and its influence on physiological studies.

the 'Integration of the macrocosmos (environment) with the microcosmos' (the human organism). The interest in this subject waned in the last quarter of the 19th century when the science of bacteriology made its beginning through the pioneer researches of Pasteur, Lister and others. In the study of diseases, emphasis was laid more on the invading parasite than on the invaded individual. With the advent of the science of immunology, serotherapy and chemotherapy, the importance of environmental influence receded more and more into the background. Whilst physiologists studied the changes produced in the system by alteration in temperature, bacteriologists tended in their first enthusiasm to disregard the physiological fluctuations and attempted to attribute every disease process to specific parasites.

The reaction to environment.

Though the interest of medicine at present is chiefly centred and perhaps rightly, on infectious diseases, the study of environmental conditions is none the less important. Let us consider how the individual reacts to his surroundings. Two methods have been devised by the organism to meet the forces of its environment. It may seek to lessen the impact and to meet the shock by increasing the resistance, in an endeavour to prevent disturbances of its equilibrium. This is usually effected by diminishing the consumption of energy or in other words, the organism becomes *less reactive*. This phenomenon of attempting to shield itself against invasion is exemplifed in spore formation and in the various forms of encystment of lower organisms. In the higher organisms, the same reaction finds expression in the mechanism of hibernation, in the deposition of subcutaneous fat and in the development of the epidermis. The other alternative is that the organism bcomes *more reactive* and instead of resisting any force disturbing its equilibrium, seeks to attune its mechanisms of equilibration to such a degree that they swing in a rhythm with the environmental force. This is seen in the development of special mechanisms for the rapid mobilization of reserves, in the unusual acuity of receptors and not infrequently, in the formation of special sense organs. Man, after all, is a living organism existing in his own particular environment and, being endowed like all living beings with powers of adaptation, he reacts to it in such ways as to produce, if possible within himself, ideal conditions for living under varying environments. This adjustment must necessarily involve fundamental physiological changes in the organism, and probably also in its powers of resistance to disease. The history of man is not inaptly described as 'an endeavour first to adjust himself to his environment and later to control that environment itself.'

The mechanisms designed to meet the environmental demands and the selection by the organism of different methods for adaptation are manifold. We will consider them in more detail

later. It is important to emphasize here that it is not enough to understand any one reaction to a single well-defined change in environment; the repercussions on other reactions must also be determined and the degree to which they affect the capacity of the individual to react to further environmental changes of a different type. Such knowledge is essential if the organism is to be understood as a unit. The problem is naturally complicated and raises many interesting enquiries.

### The Individual and his Physiological Equilibrium

The external environment with the effects of which we are concerned is not in reality the one in which the body cells live. As is well known, though the external environment varies greatly, the internal one remains remarkably constant and this is achieved firstly, by certain physical and chemical factors inherent in the saline fluids which constitute the internal environment—the '*milieu interne*' of Claude Bernard—secondly, by certain bodily reactions designed to prevent abnormality. An outstanding example is the constant neutrality of the fluids which bathe the body cells where even a slight increase in the hydrogen-ion-concentration from 0·000,000,05 ($10^{-7}\times 5N$) to 0·000,000,1N ($10^{-6}N$) might produce a serious dislocation of the vital processes. To counteract any such disturbances, there is always an effort on the part of the organism to oppose any tendency to change. This is best seen in the rapid breathing associated with all forms of muscular exercise. A contracting muscle needs proportionately more oxygen than a quiescent one; this increased oxygen usage implies an increased blood supply which again involves an augmented blood flow through the lungs and consequent increased ventilation. Similarly, the response to a rise of body temperature sets in motion simultaneously a number of complex reactions which tend to oppose any threatened alteration.

Physiological stability is a dynamic not a static equilibrium.

The apparent physiological stability of a living being which is suggested by the constancy of such characteristics as heart rate at rest, body temperature, blood sugar level, reaction of the blood, blood volume, blood pressure and composition of alveolar air, is not due to a static condition, but is only made possible by the lability and close correlation of dynamic forces which are constantly being adjusted in response to nervous, chemical or physical stimuli arising within or at the surfaces of the body. The equilibrium thus attained is therefore of an oscillatory type and is the resultant of the interplay of unstable and variable functional activities which are constantly operating in the body. Thus, the carbon dioxide content of alveolar air is remarkably constant in any individual and is controlled by the depth of respiration, which in turn is regulated by the carbon dioxide

content of arterial blood; the respiratory centre is so sensitive that it will respond to changes which cannot be easily measured by chemical or physical methods. This high degree of sensitivity maintains the equilibrium without demonstrable oscillation but the oscillatory nature of the equilibrium may be unmasked and become recognizable in certain diseases as Cheyne Stokes or other types of periodic breathing. The temperature of the body is maintained fairly constant in health, despite variations in external temperature and activity, but during illness or during recovery from illness there may be a lack of sensitivity or some degree of failure of the regulating mechanism and the least exertion may cause an abnormal rise of temperature producing profuse sweating with a temporary fall of temperature below normal. Similar examples showing the oscillatory nature of physiological equilibrium might be taken from circulatory adjustments, muscular co-ordination or from the regulation of blood-sugar level.

The range of reactivity and the limits of adaptability.

Interference with or destruction of these compensatory mechanisms will reduce the chance of recovery from accidents or diseases in which their activities are required to counteract the disturbance. A given compensatory mechanism may be adequate to maintain, under resting conditions, a physiological equilibrium within normal limits, so that the effect is not recognized until the mechanism is subjected to some stress. Thus, two individuals may have the same heart rate under the same resting conditions, but if the vagal impulses in both are eliminated by the injection of atropine, it may be found that the heart rate of one considerably exceeds that of the other. The heart rate is controlled by two opposing forces, one from the vagus and the other from the sympathetic, and although the net result of these may be the same in both before the injection of atropine, yet in the one a greater amount of nervous stimulation takes place than in the other. Again the fasting blood sugar level in two individuals may be identical and yet the injection of the same amount of adrenalin into each may cause in the one a much greater rise in blood sugar than in the other. Insulin will be less effective in the former than in the latter, suggesting that the self-adjusting mechanism in the one case is 'set' at a different level from that in the other, although the controlling factors in each case are so balanced that the equilibrium points are the same. Neither heart rate nor blood sugar level *per se* therefore gives any clue to the reserve powers of the complex systems which control these physiological characteristics. Hence the test of physiological normality is relative and is not solely or even mainly the equilibrium point of the various compensatory systems. In fact the extent to which these systems will respond, when brought into play by adverse changes in the environment of the individual, and the degree

of their response are measures of the organism's reserve capacity or power of adaptation. On this reserve power depends the success of the individual in his adaptation or acclimatization to changed surroundings and environments.

### Environment and the Mechanism of Adaptation

Physiological factors in adaptation.

Adaptation has been aptly defined as the continuous adjustment of internal relations to external relations. This ability to respond actively to changes in environment is an essential characteristic of any organism. The range of environmental adaptation of even the most primitive cell is relatively wide, although the mechanism of response may be simple; but as we advance in the scale of animal life, the range of adaptation becomes even greater as the mechanism and the means of adjustment become more complex. Thus the single-cell organism existing in a relatively stable fluid environment needs only direct adjustment to the environment and this adjustment must of necessity be a '*chemical*' one. This is exemplified in the behaviour of the protoplasm of the *myxomycetes* which, when placed on a piece of blotting paper, will crawl towards an infusion of dead leaves or away from a solution of quinine. The amoeba again can respond only to changes in the composition of the fluid in its immediate vicinity. When multicellular organisms begin to specialize, this comparatively simple chemical adjustment is not found adequate and special methods have to be elaborated by which a 'colony' type of life can be perpetuated. Individual cells of multicellular organisms begin to manufacture substances through which the different members of a cellular unit can be influenced. These substances or 'hormones' circulate in the fluids of the body, and play an extensive rôle in *hormonic* adjustment to environment. Their primary purpose is to initiate automatic reactions and to sensitize the tissues to react either more rapidly or more slowly. The higher we ascend in the animal scale, the means by which the organism responds to environmental changes become more varied and complex, and an additional mechanism of adjustment other than chemical and hormonic is called for. For this purpose, the anatomically defined autonomic *nervous* system, both sympathetic and parasympathetic, has been developed. Finally, when the level is reached at which reason is developed, not only are accomplished changes appreciated but the possibility of alteration, made or threatened, can be recognized and guarded against; in other words, the adaptive reactions become conscious and adjustment to meet them, 'volitional'. Thus, among higher animals the distance receptors (eye, ear, nose) give warning of approaching danger, while in man complex mental processes allow the possibility of altered environment to be inferred, although the actual change

may not be imminent. All the reactions of a biologic mechanism to environment may therefore be said to be mediated through three distinct but mutually related and integrated processes—*chemical*, *endocrinal* and *nervous*. The three components are functionally inseparable, and no one component can be disturbed without disturbing the others.

Reserve forces of the organism.

A living organism, whether a single cell or an integrated cell mass (the individual) may therefore be regarded as a highly unstable system, which tends to reproduce itself continuously under the average of conditions to which it is subject, but undergoes disintegration as a result of any variation from this average. The ability to maintain an equilibrium without the breakdown of the adaptive mechanism under adverse conditions determines the development of the individual and ultimately of the species. The greater the possibility of protective reaction the greater are the chances of survival. It seems important therefore to stress the fact that the animal body, although often compared with a man-made engine, differs fundamentally from the latter in that it has latent reserve forces capable of adjusting the animal to a new environment; in other words it possesses powers of adaptability. These forces call forth hypertrophy of glands and tissues in response to appropriate stimuli and even carry out repair of damaged parts. Sensibility or facility of response can be improved by frequent usage or 'training' as in the case of muscular exercise. The athlete can undertake a given amount of exercise with less disturbance of respiration and circulation than can the untrained person, and his return to the resting normal condition is also quicker. Unlike a test tube, in which chemical reactions are definitely limited, the efficiency of practically all the compensatory systems of the body can be increased by judicious use if the stimulus producing the reaction is adequate in each case.

## The Individual and his Atmospheric Environment

The most important environmental factor is the atmosphere in which we live. Hippocrates, who may be called the father of the modern science of climatology, recognized the importance of 'airs' over 'waters' and 'places' and also appreciated the different qualities of the cold and the tropical atmospheres and other cosmic influences. As the atmospheric environment is so familiar, we fail to recognize the importance of the part it plays in moulding the physiology and sometimes the pathology of 'air-living' animals. We are likely to forget that we take in as much air by weight per day as we do of food.

The atmosphere or the air-mass surrounding the earth is not stable but fluctuates from place to place and from time to time, particularly with the 'cyclonic' waves. These fluctuations

and atmospheric disturbances are normal and necessary sequences of temperature differences on the earth's surface. It is not my purpose here to examine these meteorological disturbances in detail. I only wish to draw your attention to the influences which such an unstable and ever-changing aerial environment exert on different phases of human activity—physical, mental, social, economic—and on racial development and retrogression.

Climate and climatic factors.

The term 'Climate' has been defined as the combined effects of the sun, the atmosphere and the earth upon living objects at any one place on the earth's surface. Climate primarily results from the effects on the earth's surface of the incident solar energy and its unequal distribution. For descriptive purposes, it is usually stated in terms which have reference to the so-called *climatic elements*—namely the temperature of the air, its humidity, also the amount of precipitation or rain, snow, frost, its motion, density, transparency and electrification. The climatic elements are dependent on physiographic factors, such as distribution of land and water, mountain ranges, nature of the soil, distance from the equator and height above the sea level. The latitude and the altitude are, however, the most important and deserve special attention.

Climate in the tropics.

It is generally assumed that the climates of the whole of the tropical zone are in all respects alike and therefore the term 'tropical climate' is often used, though incorrectly. Climatologists have divided the tropical belt into several sub-divisions according to the situation of the land in relation to the equator, the vicinity of water, the growth of vegetation, the presence of mountains or hills, the proximity of land to oceanic currents and trade winds, and its height above the sea level. All these factors will naturally influence the 'climatic type' of a locality. Thus the tropical zone includes deserts, damp forests, jungles, swamp lands and fertile islands refreshed by cool, steady winds from the ocean, low-lying plains and valleys under the influence of periodic oceanic monsoons, and mountains several thousand feet above sea level. All these regions are not equally disagreeable for the residents. The deserts, for example, are free from many tropical diseases, for their parched soil and dry, sterile air are unfavourable to the development and distribution of most micro-organisms and disease-bearing insects. On the other hand, the dust, heat and brilliant sunshine are very trying, and the paucity of water is obviously a serious limitation. Again, wherever mountains and plateaux occur in the tropics, the climatic conditions are distinctly different from the plain and may be actually mild and agreeable. It will therefore be seen that within the tropical zone, there may be areas with peculiar climatic types with their special advantages and disadvantages. In dealing with climate in the tropics, I shall confine myself

to the consideration of its effects in tropical plains in the latitudes near the equator.

The climate in these regions varies but little and the temperature ranges between 75°F. (25°C.) to about 115°F. (46°C.). There are no seasons in the tropical zone and monthly and diurnal variations of temperature are slight. These areas are often subject to the influence of monsoons with their alternate dry and wet spells. They are usually very fertile and support a variety of luxuriant vegetation. The study of the climates prevailing in this zone has attracted most attention because these areas have been frequently colonized by the white race. A large portion of the plains of India have a climate of this type and therefore it is of very great interest to us to know the physiological adjustments required of human beings in such a climate.

## Climate and the Individual

The influence of climate on man is so well recognized that it is often the main topic of daily conversation. One often hears of a 'bracing' climate or a 'relaxing' climate, and the beneficial effect of climatic variation finds its expression in our desire for a 'change of air'. Though we do not know whether and to what extent actual temperature, or humidity or wind affects human beings, there appears to be a direct relationship between the physical and mental vitality and the variability of climates. Huntington in his fascinating book on 'Civilization and Climate' puts forward the theory that all the world's great civilizations are now in regions experiencing often unexpected changes of weather and that the superiority of races inhabiting temperate regions of the globe is largely the result of climatic influences. Man is considered a mere creature of his meteorological environment and climate is said to rule the destinies of nations. Mills (1934–36) has corroborated some of Huntington's conclusions. According to him, there are energy differences between the races living in warm climates and those in temperate climes which cannot be accounted for on the basis of diet and mode of living alone. The tropical person has a lower oxygen consumption, a lower blood pressure and a lower capacity to meet emergencies than the resident of temperate zones. Some psychologists maintain that each climate tends to develop its own characteristic mentality. In other words, climate not only modifies the physical features but also the nervous system of the individual. These and other similar questions raise interesting issues which are not easily answered. Because of the difficulty involved in the study of the direct effects of climate on the individual, the data recorded in the literature are very discordant. There is a school of thought which maintain that too much stress is laid on climatic factors by Huntington and Mills and that many of their generalizations probably are not based on a rigidly scientific and critical

evaluation of facts. While it is not possible in the present state of our knowledge to give any definite opinon, there appears to be little doubt that climate plays an important rôle, though often an indirect and subtle one, in the production of many physiological changes in the organism and as a predisposing cause or an accessory cause in many disease processes. I propose to examine some of these changes in the subsequent sections. It will suffice here to indicate that though man can live in any region where food and water can be obtained he can best develop his physical and mental capabilitios under the most favourable environmental conditions. There seems but little doubt that there is also a distinct optimum condition for man, just as for plants and animals and any departure from it adversely affects the organism.

## Effects of Heat and Sunlight in the Tropics

In considering the effects of residence in tropical climates, attention is at once directed to three major environmental factors, *viz.*, *temperature*, *humidity* and *sunlight*. There are a number of other climatic and environmental factors such as wind movement, atmospheric electricity, ionization, etc., which also affect the human organism, though the responses elicited do not leave lasting impressions on the individual. In nature, all these climatic factors operate simultaneously and the reactionary changes observed at any one time are in most cases a summation effect, one factor being superimposed on the other. Thus while the acute effects of encountering very high temperatures as of a heat wave or in a desert region may be tolerated without harm, the organism may show signs of intolerance or breakdown when excessive humidity is superimposed on such a high environmental temperature. This interdependence of several climatic factors makes the analysis of the effects of different components which constitute the 'climatic drive', a difficult matter and is mainly responsible for many of the conflicting views which have been expressed. Let us consider each of these factors separately and see to what extent each component contributes to produce the resultant total effects.

Sunlight.

The biological effect of sunlight has received perhaps more attention than any other factor in this group. A careful perusal of the literature has convinced me that the knowledge gained in this branch is indefinite and unsatisfactory. The beneficial results obtained by heliotherapy in tuberculosis and the effects of ultra-violet light in the treatment of rickets created the impression that the ultra-violet portion of the spectrum was the important factor responsible for the biological effects produced. Several investigators in the tropical belts of Australia, the Philippines and the Netherlands East Indies have adduced experimental evidence indicating that

the ultra-violet light, being non-absorbable by the skin, is probably much less important than the infra-red and the visible-red end of the spectrum, which penetrate the superficial layers of the skin and are perceived by the organism as heat energy. Whatever direct effects tropical sunlight may have has therefore been attributed to its thermal action. Petersen (1936) has, however, shown that ultra-violet rays may produce physiological effects by first sensitizing the skin and then inducing a reflex stimulation of the thyroid and other glands of internal secretion. It is difficult in the present state of knowledge to evaluate the evidence with regard to the part played by the different components of the spectrum in producing physiological reactions in the individual.

Humidity.

The effect of humidity on the human organism has recently engaged the attention of public health authorities and sanitary engineers interested in environmental control through air-conditioning methods. That humidity modifies, to a great extent, the effects of heat is generally recognized. A moist humid atmosphere is associated with depression and discomfort and conversely, dry air, irrespective of its temperature, induces a feeling of comfort and well-being. The water content of the atmosphere must affect the water content of the body. In the regions of high environmental temperature such as are met with in the plains of India for example, greater humidity will prevent proper evaporation and heat loss with resulting disturbances in the respiratory exchange in the carbon dioxide content of the blood, and consequently in the water and ion balance. It may therefore be stated that high humidity, by diminishing evaporation of sweat merely aids in increasing the effects of heat, but as a direct factor it does not appear to possess any great specific importance.

Temperature.

Studies on the changes produced in the body of man as a result of exposure to high environmental temperature have been numerous, but, like most aspects of tropical physiology, the data are conflicting. It has been reported that a change in the environmental temperature produces a change in the *body temperature* of the individual and that in the tropics body temperature may be permanently above the average in the temperate zones. Though a large amount of work both in man and in experimental animals has since been published, the position is still undecided. While it is true that a change in the body temperature of an individual may be easily affected for brief periods by exposure to high external temperatures, it is doubtful if, in view of the sensitive heat-regulating mechanism in man, a permanent change can be brought about by prolonged exposure such as residence in the tropics. The same argument may be adduced against the contention of some workers that the *skin temperature* is raised in tropical zones. From physiological considerations, it is

logical to assume that the flushing of the skin, as a result of exposure to a hot environment, raises the skin temperature, but the temperature soon drops when perspiration breaks out. It has also been suggested that darker coloured individuals in the tropics possess a higher skin temperature than the light coloured ones. This statement also has not been confirmed.

Regulation of body temperature.

The chief climatic factor affecting the individual in the tropics being the high environmental temperature, the adaptation that he is called upon to make is naturally one of heat regulation. This is accomplished by a fine balance between *heat production* and *heat dissipation*. Heat is always produced in the body by the metabolic activities of the protoplasm and, if life and the power of work of the individual are to be maintained, this heat production cannot be reduced below a certain minimum. Hence, heat regulation of the individual is more often effected through modifications of the various mechanisms available for heat loss, than through changes in heat production.

Heat loss and rôle of pigment.

It was generally recognized that tropical races are at an advantage over the European settlers in the matter of heat dissipation. The possibility suggested itself that acclimatization for generations in a climate where the mechanism of heat loss had to operate under excessive strain might have endowed the skin of the tropical races with an additional power and facility in getting rid of excess heat by the processes of physical heat regulation—conduction, convection, radiation and evaporation—at a more rapid rate than in individuals from cooler zones. It has been claimed that the skin of tropical races loses heat by convection more rapidly than the skin of white races but these conclusions have not been universally accepted. The suggestion next put forward was that the dark skin radiated heat quicker than the white skin, but satisfactory evidence has not been obtained in favour of this contention. It is therefore difficult to state with any degree of certainty whether the presence of pigment in the skin confers any real advantage so far as heat loss by *radiation* is concerned. There is however little doubt that pigment plays an important part in heat regulation by other channels. Owing to the high absorption coefficient of melanin, heat is rapidly produced in the skin; this stimulates the local heat receptors with consequent reflex sweating. Moreover, pigmentation of the skin is necessary to protect the deeper structures from the injurious effect of sunlight and to protect the sensitive cutaneous nerve endings from irritation. The brown-skinned races in the tropics, by virtue of the pigment, have apparently developed a more sensitive cutaneous heat-regulating mechanism, and they can cool off more rapidly by reason of the early formation of a fine layer of sweat drops. It is generally admitted that Europeans who tend to take on pigmentation are

on the whole better acclimatized to the tropics than those who do not darken. The studies of Acton in the School of Tropical Medicine on the pigments of the normal skin of Europeans and Indians are of interest in this connection. He found that the pigments present in the basal cell layer of the epidermis of the two groups did not differ in the actual amount (quantity), but in their chemical composition (quality). The pigment present in the Indian skin was deeper brown in colour and showed a distinct tendency to increased chemical reaction with 'dopa-oxidase'. The significance of this is not yet clear. The precursor of melanin is dioxyphenylalanine which is again a breakdown product of the amino-acid, tyrosin. It is possible that the differences in the diet and metabolic rates in the natural tropical inhabitants might be ultimately associated with the production of a chemically distinct type of pigment in the skin. The distribution of pigment may also play a part in bringing about the adaptation which the tropical inhabitants are supposed to possess. Thus, in negroes, histological evidence shows that pigmentation is deeper and more diffusely spread than in the white races where the pigment is contained chiefly in the malpigian layer and in the superficial layers of the corium.

Sweat secretion.

For physical heat regulation, however, the activity of the sweat glands is of outstanding importance. Their efficiency depends on several factors: (1) humidity of the environmental air, (2) concentration of sweat glands per unit area, and (3) the degree of activity of these glands. Humidity, does not in actual practice exert a great influence, because apparently high degrees of humidity, provided they fall short of absolute saturation, can be borne by the system with impunity. The concentration of sweat glands in the skin may regulate the amount of perspiration, and it was believed by many early workers that the better heat-tolerance of the dark-skinned races was probably due to this factor. Though some investigators have reported a greater concentration of sweat glands per unit area of skin surface among them, these findings have not been corroborated. From the point of view of heat loss, increased concentration of sweat glands cannot be considered specially significant as the quantitative outpouring of sweat is less important than its distribution on the skin to form an even film which leads to rapid evaporation.

Composition of sweat.

A study of the composition of sweat produced in extreme dry heat shows that there is an adaptive response on the part of the organism and that the concentration of salt in sweat decreases after the first few days in the hot environment. To cite a concrete example, the amount of sweat produced with ordinary type of work in a climate such as that of Calcutta (95°–105°F. or 35°–41°C.) may be as much as 7 litres during the day. Assuming a sodium chloride concentration of 0·3 per cent., this means a loss of 22·5 gm. of

salt. Man's daily intake of sodium chloride is 10 to 15 gm. and since the average normal excretion of salt in the urine is in the neighbourhood of 12 gm. in 24 hours, the degree to which muscular work in such a climate may deplete body chlorides is remarkable. If this depletion is not compensated, the normal acid-base equilibrium of the body fluids is apt to be seriously disturbed and heat cramps from loss of salt may supervene. It seems clear that some sort of adaptation takes place in normal healthy individuals. Little is known, however, of the nature of this adaptation, though it has been noted that all men sweat more readily as they get accustomed to exposure to heat. This increased 'ability to perspire' is known to be one of the few definite adaptations to high temperature and it is interesting to note that it is a case of 'controlled' rather than profuse wasteful sweating. The sweat secreted is said to contain an unusually low concentration of sodium chloride and this would appear to be an attempt at conservation of chlorides, as even on a high chloride intake their concentration remains low.

## Effects on the Digestive System

Atonia and stasis.

It has frequently been observed by Europeans coming to the tropics that there is a definite impairment of appetite and a lessened desire for animal food. Though this may indicate a diminished power of digestion, it is probable that the disinclination for animal food may be an adaptive response to a lower caloric need in the tropics. There is also a tendency to an atonic condition of the gastro-intestinal tract, as evidenced by an increased tendency to stasis with resultant constipation and gaseous distension. This may be due to sedentary habits and lack of exercise though it is perhaps largely due to the fact that Europeans in the tropics are apt to follow their old dietary habits suited to temperate climates and do not take enough carbohydrates, vegetables and water to provide for the roughage. On the other hand, it is possible that the high environmental temperature in the tropics leads to a vaso-dilatation of the skin capillaries and a reflex vaso-constriction and anæmia of the splanchnic area, resulting in diminished gastric and biliary secretions and possibly also, in an atonic condition of the stomach and intestines. Muller and Petersen (1936) called attention to the fact that, with skin stimulation, the activity of the mucous membrane of the stomach and gastro-intestinal tract was decreased, but with lessened activity of the skin (as with cold) the functional activity of the mucous membrane of the gastro-intestinal tract was increased. It is probable that the inhabitants of warm climates make an appropriate physiological and dietetic accommodation by the greater use of condiments. Spices in solution are known to increase the activity of the villi and secretory glands, and the

free use of condiments in the tropics may be an expression of the greater need for gastro-intestinal stimulation where skin activity is normally unduly accentuated.

Gastric acidity.

A general impression seems to prevail that gastric acidity of rice-eating Indians is lower than that of meat-eating Europeans. Napier and Das Gupta (1935) carried out a fractional gastric analysis on a number of normal Indian male and female subjects and found that on the whole their gastric acidity was higher than in normal Europeans. This is contrary to expectations, for hot climate and vegetarian diet are both believed to be factors that tend towards decreasing gastric acidity. No explanation of this phenomenon is yet forthcoming.

Bacterial flora.

Bacteriologists have claimed that the bacterial flora in the intestines of inhabitants in the tropics are different from those of colder climes. Arnold (1934) has shown that the bacterial flora of the lower intestinal tract vary with external temperatures and hence it is natural to expect a difference between those found in the tropics and the cooler regions. As the nature of the food is also known to influence the relative proportions of the various bacterial groups in the intestinal flora, and as the predominant dietary constituent in the tropical inhabitants is carbohydrate, the claim has much in its favour. Workers in this field appear to agree that an animal protein diet encourages the growth of proteolytic types, whereas the addition of lactose and dextrin stimulates the development of aciduric micro-organisms. Normally, a sufficient amount of lactose in most instances will cause a complete transformation of an ordinary mixed flora into one consisting predominantly of streptococcal and lactobacillary types. It has for instance, been recently shown that banana powder, apple powder, and raisins, when fed to white rats subsisting on a high protein diet, consisting exclusively of raw chopped beef, produce a change in the intestinal flora from one in which non-aciduric bacteria predominate to one in which *Lacto-bacillus acidophilus* is the outstanding organism. It has been further pointed out that the simplification of the intestinal flora varies directly with the hydrogen-ion-concentration, a *p*H of 7·0 being characteristic of a gas-producing proteolytic type, whereas an increasing acidity is characterized by a diminution of proteolytic types and the replacement by the aciduric types. It is evident, therefore, that a diet containing sufficient carbohydrate is capable of effecting a complete turnover from a heterogenous gram-negative type of flora in persons fed on high protein diet, to a flora markedly simplified and gram-positive, inducing coincidently a change in the hydrogen-ion-concentration from nearly neutral to distinctly acid.

Recent work (1937) on the hydrogen-ion-concentration of fæces of different classes of persons living in Calcutta shows

that, whereas the reaction of the stools of most of the Bengalees is acid, those of the Europeans, Anglo-Indians and Marwaris is mostly alkaline. Although the Marwaris are vegetarians and live on a predominantly carbohydrate diet, they consume very little of rice and take more of wheaten bread (*chapati*). It would appear that the consumption of rice produces an acid reaction in the large intestine while wheat produces an alkaline reaction. When Bengalees were put on bread, and rice was cut off, the reaction of the stools changed from acid to alkaline in most cases. In view of the acidity of the stools, it was thought likely that aciduric organisms would predominate in the stools of Bengalees, but surprisingly enough *Lactobacillus acidophilus* could not be isolated.

With regard to bacterial flora in the normal intestinal canal of Indians and the differences, if any, that may exist in this direction between Indians and Europeans, our knowledge is far from complete. In an extensive survey of the bacterial flora carried out in the School of Tropical Medicine, a non-lactose fermenting gram-negative bacillus (*B. pseudocarolinus*) was frequently isolated from normal healthy individuals in Bengal. This organism is not present in the stools of Europeans who have never come to the tropics. It appears to have no definite relationship to the dysentery group of organisms excepting that it is sometimes lysable by dysentery phages. In this connection it is interesting to note that *Monilia psilosis* which according to Ashford (1924) is the causal organism in sprue is frequently found in Calcutta in the stools of persons, who are definitely not suffering from this disease. It is not possible in the present state of our knowledge, to state definitely whether such organisms are normal inhabitants of the intestine or whether they play any part in the causation of the disease.

## Effects on the Respiratory and Cardio-vascular System

Frequency and depth of respiration.

There is good deal of divergence of opinion with regard to the effects of tropical climate on respiration. According to some, the frequency of respirations is decreased while others hold that it is increased before acclimatization. The consensus of opinion appears to be that the rate is diminished but the depth, as indicated by measurements of the minute volume, is increased. A slightly deeper breathing is more efficient for the individual, economizes energy and at the same time, the increase in the volume of air breathed cools the system. These changes in the rate and vital capacity are probably of a temporary nature, evident only in the case of the white immigrants to the tropics, and are not apparent in the natives of the tropics. Thus, it has been repeatedly shown that the respiration rate in the native residents of India, Java and the Philippines does not show

significant changes as compared with the standards obtained in the cooler countries of the West.

Pulse rate, blood pressure and blood volume.

A slight decrease in the pulse rate and in systolic blood pressure are very common findings in the tropics. Mills (1936) has shown that people migrating from West Central Europe or Central North America to the tropics nearly always suffer a marked fall in blood pressure within a year or two, even though no debilitating disease or infection has occurred. Probably there is a slight decrease in blood pressure due to lowered vaso-motor tone and a general slowing of physiologic activity in the high environmental temperature in the tropics, but the changes are comparatively insignificant. The increase in sweating which is necessary in the tropics must require a constantly increased blood supply to the skin, and has been estimated to be as much as 50 times of the amount in temperate climes. The immediate result, if the total volume remains constant, would mean relative anæmia of the splanchnic region and the vital organs in the abdomen. To counteract such circulatory disturbances there is usually an increase in the total blood volume. Barcroft and his co-workers (1923), in an expedition from England to Peru found that the blood volume increased as the tropics were entered. The rise in blood volume was accompanied by a fall in hæmoglobin indicating that this was a simple dilution effect, blood plasma being drawn into the capillaries from the tissues. These results signify that the organism in the tropics, becomes at least temporarily 'wetter' and so is able to sweat more easily and plentifully.

Hæmatological standards.

The pale complexion of the white races migrating to the tropics has been frequently referred to as an indication of anæmia or 'thinness of blood'. Most authorities are of opinion, however, that a tropical climate *per se* does not produce true anæmia. Several workers in the Dutch East Indies including Eijkman (1924) found that the values for red blood cells and the hæmoglobin lay more or less within the same limits for the white sojourner and the native residents of the tropics. Dhar (1937) in Calcutta studied the normal hæmatological standards of a large number of Indian women and found that the average values for hæmoglobin, red cells, mean diameter of red cells and leucocytes are lower than the average figures reported in the European, American and Japanese literature for the same age groups. Indeed, the normal average hæmoglobin value which this worker obtained (11·47 gm.) for Indian women would be considered in Europe and America as bordering on anæmia. Napier and his co-workers (1937) at the School of Tropical Medicine, on the other hand, have not obtained any evidence that the hæmoglobin level in the Indians and in the healthy Europeans in India was low. In the healthy male Europeans the hæmoglobin was

usually about 125 per cent. on the Haldane scale (17·2 gm. per 100 c.c. blood) and seldom below 120 per cent. (16·6 gm.). This is much higher than the 'normal' figure usually quoted for Europeans in Great Britain. In two series of normal healthy Indians consisting of 50 and 30 individuals the mean hæmoglobin contents were found to be 14·77 gm. and 15·70 gm. respectively. Sokhey (1932) in Bombay got a mean of 15·11 gm. in a large series. These figures are not materially different from the normal figures given for males in Great Britain and, if anything, are slightly higher than the standard figure of 14·5 gm. given by Price-Jones. With regard to the number of red cells, the average figures obtained in the Calcutta series were 5,533,000 and 5,362,000 and the mean of the Bombay series was 5,110,000. These figures are again above the classical 5,000,000. Even if the figure of 5,428,000 given by Price-Jones is considered as the normal mean count, the figures obtained in the Indian series are not much below normal and there is no reason to believe, that the size of the red cell differs from that in cooler climates and the colour index, volume and saturation indices are all in the neighbourhood of 100.

Most hæmatologists in the tropics appear to agree that the white blood cells are generally decreased though the change is not very great. As a rule the poly-nuclears have been found reduced and the Arneth count shifted to the left. This has been fully confirmed by workers in Iraq and by Dharmendra (1937) in Calcutta. Napier (1935–37) found that the number of leucocytes if it differed at all, was slightly lower than in temperate climates, but the eosinophile percentage was definitely higher. In 50 normal city-dwelling Indians who had no heavy helminth infections, the mean eosinophile percentage was nearly 7·0. Not only is the normal eosinophile count of the Indian high, but in disease the eosinophilia tends to attain a very much higher proportion than in the Europeans in temperate climates, *e.g.* 60 to 80 per cent. eosinophilia is not uncommon in asthma and other conditions.

It is not possible in the present state of our knowledge, to explain the significance of the different hæmatological responses observed in the tropical races. From the findings of Napier and workers in the West, it seems reasonable to conclude that, far from interfering with the functions of the erythropoietic organs, the tropical climate may actually exert some stimulating action on these organs. The possible bearing of the low average white cell count on the defensive mechanism against disease processes requires further investigation.

Biophysical and biochemical changes in blood.

There is little doubt that there is a more pronounced disturbance of water metabolism and water movement in the tropics than in temperate surroundings. This will naturally be reflected in the water content of the blood. A number

of observers have attempted to throw light on this important aspect of tropical adaptation by measurement of blood chloride concentration. Sundstroem (1925) working in Australia found that the blood plasma was more concentrated than normal and richer in chloride content in a hot environment. As the formed elements of the blood actually became richer in water, it was probable that there was a shift of water from plasma to corpuscles. Barbour (1924-5) showed that there is considerable dilution of the blood prior to and accompanying the outbreak of sweat in hot and humid environment. This hæmodilution may be only temporary as the heat loss through evaporation may reach such proportions that the water in the red cells may be drawn upon to supply the water for perspiration. A slight alkalosis has been reported particularly in persons of sedentary habits which can be removed by water intake and muscular exercise.

The average concentration of serum proteins in the blood of Indians according to Chopra and Mukerji (1931) appears to be slightly lower than the accepted standard figures of Europeans, but the albumen-globulin ratio remains unchanged. The results with regard to non-protein nitrogen content are not conclusive. Since protein intake is likely to be low in the tropics, this will probably be slightly lower than normal. The lipoid constituents of the blood including cholesterol have generally shown lower values. Blood sugar apparently is not much affected by the climate though it was generally believed to be high in the tropics. In view of the common belief that the tropical climate tended to produce an increase in blood sugar, it was thought that diabetes was more common in the tropics. The studies of Mills (1930) have shown, however, that diabetes is more common in the temperate climes. Serum calcium is appreciably increased, probably as a result of excessive production of vitamin D from ergosterol due to the radiant energy of the tropical sun. Sundstroem reported a reduction of total phosphorus, but the finding has not been confirmed.

### Effect on the Nervous System

That hot environment actually disturbs the psychological reactions of the individual migrating to the tropics is generally admitted; but it is doubtful if the climate alone is responsible. The climatic element along with a large number of other factors, *viz.*, social hygiene, isolation, sedentary habits, alcohol, etc. undoubtedly plays a part. There is, however, a physiological basis for the concept that the higher centres may be influenced by a series of stimuli from the peripheral sense organs and there is a theoretical possibility that the nerve cells in the brain might be exhausted or fatigued if the stimuli are of a type to which the nervous system is not ordinarily accustomed. There are many instances where a close correlation of a pathological nervous

state can be made with changes in the climatic and meteorological factors. It is, for example, well known in epileptic colonies that the fit-incidence rises when the weather is close and sultry, and before and during storms. Migraine is likewise affected by the weather. Victims of chronic pain have a peculiar interest in the weather. Neuralgia, locomotor ataxia, and other painful diseases are always aggravated when it is damp, cold and windy. The weather may influence the course of chronic psychosis and unfavourable conditions may exaggerate pre-existing states of either depression or excitement.

Tropical irritability.

The intense heat and the bright sunlight of the tropics are the two factors which have been most commonly incriminated as agents in weakening the control of the higher centres over the lower and causing the so-called 'tropical irritability and neurasthenia'. Pediatricians in the tropics have often said that in children, memory, initiative and application become bad after the tenth year. It appears however that the measureable physiological disturbances are on the whole not very significant. It has so far not been possible by physiological, psychological and biochemical methods to furnish the desired evidence for altered functions of the nervous system. There may be, however, nonmeasurable and subtle nervous effects which may be of fundamental importance in the problem of acclimatization. Residents in the tropics are less prone to feel the depressing effects of a continuous high temperature and humidity, and the nervous effects observed among white settlers are conspicuous by their absence in the natives. There is probably no impairment of the higher psychical reactions and memory traces in the former as has been claimed for the white sojourners.

## Effect on the Endocrine System and Growth

It has often been observed that the endocrine glands may be disturbed in tropical climes. The association of increased metabolism, high energy level and higher incidence of metabolic diseases in a cooler climate and a sluggish metabolism, a low energy level, decreased resistance to infection and lower incidence of metabolic diseases in a tropical climate are generally recognized, and it is probable that all these factors are ultimately bound up with the question of the activity of the glands of internal secretion.

Thyroid-adrenal apparatus.

Much experimental data both physiological and pathological have been collected, indicating that the thyroid-adrenal apparatus may be affected in a hot environment. The defective heat regulation of patients suffering from myxœdema directed the attention of workers to the reaction of thyroidectomized animals to changes in temperature. In the thyroid glands of animals

reared in a hot environment definite histological evidence of a diminished colloid content has been found. Cramer (1930) adduced evidence to indicate that the activity of this gland is diminished after experimental heat exposure for a certain length of time. So far as the suprarenal gland is concerned, a relationship between this gland and heat regulation has been established by showing that exposure to cold is a powerful stimulus to its functional activity. According to Mills (1929) definite disturbances of body function may result from too prolonged and severe moist heat due to hypofunction of adrenal glands.

That the thyroid-adrenal apparatus is concerned in the heat regulation of the body, is borne out by pathological evidence. Lesions of these glands are frequently accompanied by marked disturbance of heat regulation, and conversely disturbances of heat regulation as in fevers, frequently produce lesions in these glands. High temperatures are known to affect adrenalectomized animals more easily, and frequently they die in a temperature which is not serious for the control animals exposed for the same length of time. All these facts indicate that there is a lowered resistance to heat in adrenal insufficiency.

These facts enable us to speculate on the close inter-relationship that exists between heat regulation and the thyroid-adrenal system and which afford a physiological basis for the study of the fascinating problem of the influence of climate on man. It has often been noted that a warm, moist climate with little change from day to day is 'relaxing'. This might be the result of a failure to stimulate the thyroid-adrenal apparatus and through it the sympathetic system. Conversely, the cool variable climate, which is associated with increased activity and energy, probably provides a continued stimulus to these endocrine organs and the sympathetic. Mills (1932) considered that it is by whipping up the glands of internal secretion (especially the thyroid, adrenals and pancreas) that the human organism responds to weather stimulation. The same explanation may be applied to the relation between climate and health. Why is the resistance against certain bacterial infections such as tuberculosis, increased by a suitably cool, dry climate, and by measures such as open air treatment, hydrotherapy and the like? Hitherto, it has been thought that such measures increase the metabolism. An increase in metabolism, however, can be induced by other means such as muscular exercise, but this is likely to do more harm than good. The answer to the question probably is that those measures are beneficial which stimulate the thyroid-adrenal apparatus without exhausting it and thus strengthen the normal reactions of defence of the organism against bacterial infections. Conversely a warm, moist, monotonous climate weakens resistance against infections, not because it reduces metabolism as many have thought, but on account of the continued absence

of a stimulus to the thyroid-adrenal and the sympathetic apparatus.

Sex glands.

It has often been stated that girls in tropical and sub-tropical regions menstruate at a comparatively early age. It is also a well-known fact that women marry and bear children earlier in warmer countries than in cooler regions. These facts have led to the belief that the tropical climate induces premature sex maturity. There is, however, no direct proof of this as no reliable statistics are available. In India, various ages, ranging mostly between twelve and thirteen years, have been given for the onset of menstruation. These figures are probably derived from observations on the time of motherhood. The mean age for the beginning of menstruation is 15 to 16 years among the negroes on plantation in Jamaica and Barbados. Greater stimulation and earlier maturity of the sex glands has been observed in North American States where the climatic changes are more frequent and more severe throughout the year. Mills and Senior (1930) have collected data to show that human fertility, as indicated by the conception rate. depends on seasonal variations in the temperature. The maximum conception rate is always found when the mean monthly temperature is around 60°F (15·6°C.). Mean temperatures above 70°F (21·1°C.) and below 40°F (4·4°C.) produce a definite depression in conception rate. Ogle (1934) confirmed these observations by experiments on animals and showed that white mice subjected to warm humid environments exhibited a low fertility. These results would indicate a definite depression, instead of a climatic stimulation of the gonadal activity of the females in the hot and humid regions of the tropics.

## Basal Metabolism in the Tropics

The question of the influence of climate on the basal metabolism of the individual is an important subject and has received considerable attention during the last 3 or 4 decades. No satisfactory evaluation of the effect of the climate on metabolism, however, is possible even to-day, in view of the wide divergency in the results recorded. A review of the work carried out in tropical and subtropical regions in different parts of the world shows discordant results. Time will not permit me to make a detailed survey of the evidence presented by different workers but I will refer to the work carried out in India which is typical of that done elsewhere. Mukerjee (1926) experimenting on 15 Bengali medical students, found that the basal metabolic rate was on an average 9 per cent. lower than the European standard (Sanborn Standard). Sokhey (1927) found that in 15 out of 21 students, the basal metabolic rate was 10 to 23 per cent. lower than that of the Du Bois standard. This was further confirmed by Mason and Benedict (1931) who found the

basal metabolism 16·9 per cent. below the Haris-Benedict standard or 17·2 per cent. below Aub-Du Bois standard. Mukerji and Gupta (1931) showed a decrease in the basal metabolic rate by 13·3 per cent. below the Du Bois standard. Krishnan and Vareed (1932) working in Madras found that the basal metabolic rate was 12 per cent. lower in man and 16 per cent. lower in women as compared to Du Bois standard. It is not yet agreed whether this lower metabolism is the result of the tropical heat (Rahman, 1936) or is produced by some dietetic or racial factor (Mason and Benedict, 1931). Bose (1934) carried out a large number of observations by the Sanborn technique at the School of Tropical Medicine and came to the conclusion that the basal metabolic rate of healthy normal Indians living mostly on a mixed diet does not differ materially from the accepted standards of Europeans and Americans.

Taking a general view of the whole problem, it would appear that the observations of the majority of the workers who studied metabolism in the tropics are in agreement that there is either a slight decrease or no significant difference in the basal heat production in people living in the tropics as compared with the inhabitants of the cold or temperate regions. It seems inconceivable that such a fundamental factor as basal metabolism should be affected by climate to any great extent any more than the body temperature. A very low or high basal metabolic rate reported in the literature is probably due to uncontrolled observations or possibly some fault in the technique employed.

## Diet and Adaption in the Tropics

Protein and fat requirements.

Among all the demands which the body makes on its environment that for food is of outstanding importance, and it is to-day becoming well recognized that correct nutrition may profoundly affect the well-being and the social value of the individual. Considerable attention has therefore been directed to the adjustment of diet for different deficiency diseases and on the question as to how a well-balanced diet, containing all the proximate principles and other important constituents (vitamins, etc.) could be made available to the masses. Caloric value of food-stuffs which was at one time the basis of dietetic studies, is for the time being relegated to the background, and comparatively less attention is now being paid to their energy and heat-producing properties.

As pointed out before, the adaptation which man is called upon to make in the tropics is primarily one of heat regulation. The problem of diet is intimately connected with the problems of heat regulation, body temperature and metabolic rate, and any one of these factors cannot be considered without reference to the others. Though considerable work has been done on

different aspects of dietetics, the question of the suitability or otherwise to the tropical climate of the common food-stuffs available in the tropics is not satisfactorily answered. Nature offers fat and protein in the arctic regions and carbohydrates at the equator, and man in these areas has always accepted them as his staple foods. The old idea that the diet which a race has adopted in a particular region is best suited for its needs has been refuted, in the light of modern research on ill-balanced dietaries and nutritional diseases in those areas. It is not yet clear as to what is the optimum or ideal to be aimed at with a view to effect a suitable adjustment to the climate.

The proportion of protein, fat and carbohydrate varies considerably in the diets of different races, depending largely on the type of food available and also upon the customs existing in particular localities. The prevailing diet of the masses in the tropics is derived largely from vegetable sources and carbohydrates generally predominate in it. Nearly a century ago, Chevers thought that the Hindu dietary with a very moderate quantity of animal food was the one most suited for a tropical climate. It will be of interest to examine how far the generalization of Chevers is justified.

Biological value of proteins.

The protein requirement of the tropical races has been the subject of intensive investigation and research by a large number of workers in India and other tropical countries, but no definite conclusions have yet been drawn. It has been pointed out that in many parts of the world those who consume a diet with high protein content have a better physique and are more virile than others of the same race who, for one reason or another, consume less protein. In the north of Italy, for instance, where the protein consumption is higher, the physique is better than in the south. The same statement has been made about India although here racial differences may have something to do with the differences. McCay said about a quarter of a century ago— 'As we pass from the North-West region of the Punjab down the Gangetic plain to the coast of Bengal, there is gradual fall in the stature, body weight, stamina and the efficiency of the people. In accordance with this decline in many characteristics, there is an accompanying gradual fall in the nutritive value of the dietaries'. McCarrison working in South India confirmed the findings of McCay and concluded that there is a chronic protein starvation in the dietary of the Indians. Recent researches by Ackroyd and Wilson in this country have shown that the main deficiency in the diet is the lack of proteins of high biological value and certain salts, and this defect in the dietary, which can be easily corrected with small quantities of milk is responsible for the malnutrition and consequently the poor physique of the children. On the other hand, the fact cannot be overlooked that the meatless diet of some of the finest soldiers of the Indian

army has a low protein content. There is already a considerable volume of opinion that the protein intake in the tropics should be less than in temperate climates and the Chittenden and Voit standards of protein quota may not be applicable to the Indian dietary. It is well known that protein food, by virtue of its specific dynamic action, generates a good deal of heat. The Eskimos who live in the arctic zone, consume large quantities of meat, sufficient to raise their metabolism over 50 per cent. which is an obvious practical advantage. Such a diet in the tropics would be considered unsatisfactory as it would throw an additional burden on the heat-regulating mechanism which is already over taxed. From this point of view a low protein vegetarian diet seems logical and advisable in the tropics. Recent researches tend to show that there are a number of important factors which deserve special attention in determining the minimum quantity of protein necessary to preserve nitrogenous equilibrium, *e.g.*, the particular protein the subject is accustomed to take and the ratio of the inorganic bases to inorganic acids available to or formed in the body of the subject. The coefficient of absorption also varies enormously in proteins of animal and vegetable origin. Inhabitants in the tropics usually obtain a large percentage of their protein requirement (70 to 80 per cent.) from vegetable sources while Europeans do not draw more than 25 per cent. from this source. Vegetable protein is said to have less 'biological' value than animal protein. It is futile to work out an allowance of say 80 gm. of protein per day, if a good portion of it is derived from vegetable sources with poor 'biological' value and it may not be assimilated. Then again, a food may show variation in the absorption of its protein content merely because of various methods of cooking. For instance, *dals* (lentils, commonly used in Indian dietary) if not properly cooked lose a lot of protein value. If they are simply boiled until soft, as is usually done and consumed, about 40 per cent. of the protein content is lost from non-absorption. If, on the other hand, they are mashed and cooked with special attention to the temperature and water content, the loss is not so great. This also applies to rice which is the staple article of diet over a large part of India. A diet, theoretically perfect, may still be quite unable to supply the physiological needs of the race for whom it is intended. It is therefore of utmost importance that in assessing the amount of protein in a diet, its source should be known and the computation for protein requirements made, with special reference to the manner in which it is going to be available for final consumption.

**Fat-free dietary.**

It is a common experience in the tropics to find that the poorest classes live on an almost fat-free diet. The very small amount of fat that they do eat is also often adulterated. Thus, mustard oil which is consumed by quite a large section of the population in Bengal

is often impure and contains adulterants ; the palm oil of other tropical dietaries is very variable both in fat and vitamin content. That fat is an important constituent of diet has been long known but that it is also an essential constituent which cannot be replaced entirely for instance by carbohydrates was not realized before. Recent researches have forcibly stressed the fact that fats, if completely excluded from the diet, might lead not only to stunted growth but also to the development of various lesions indicative of malnutrition in the body. The fatty acids in fat are probably quite as important as the fat-soluble vitamins. From these considerations, it is logical to conclude that the almost fat-free diet of the Indian races is an important cause of the general and wide-spread malnutrition. From the point of view of adaptation to a tropical environment a diet comparatively poor in fat has obvious advantages. In the colder parts of the world, where harder physical work can be, and often is performed, a fairly high caloric intake is necessary and this cannot be supplied without including a generous proportion of fat. A caloric intake of a Canadian lumberman of 9,000 for example, could not be consumed as starch without putting too much strain on the demands of the alimentary canal. Fat is much less bulky than cereal foods and, bulk for bulk, is a much richer source of energy and heat. Besides in the tropics an unduly large layer of body fat external or internal is not so neces ary as in the cooler regions, which naturally leads to a diminished demand for it in the dietary.

Carbohydrates in the dietary.

Carbohydrates have a definite and important effect on the physiological mechanism of the body. Numerous workers have noted that a change from a fat diet to a starch one involves considerable retention of water and *vice-versa*. Some of it is taken up by the stored glycogen and some as extra fluid in the extracellular and probably intracellular fluids. In other words, on a carbohydrate diet, an increased amount of water is available for evaporation and urine secretion in case of necessity. Moreover, carbohydrates are always the first to be metabolized and hence *pari passu* more motile fluid is available while they are being consumed. Experiments on rats on a fat-free diet have shown that these animals consume more water and excrete actually less urine than others with fat in their diet. More fluid appears to be eliminated by the lungs, under such conditions. Further, pulmonary ventilation is greater when carbohydrates are being burnt, owing to a larger output of carbon dioxide per calorie of heat than on a fat diet. This would increase the heat loss by evaporation of water from the lungs. These experiments are suggestive in view of Eijkman's (1924) observations in Java. He found that the Malayan is more economical (physiologically) in his water elimination than the European. Under identical conditions, a European lost 143 gm.

of water and a Malayan only 105 gm. of water by insensible perspiration in a given period. Contrary to expectation, the Malayan had also the smaller volume of urine, even though he had received extra water, while the European had been deprived of it during the observation. The European appears to waste water as liquid perspiration which does not therefore perform its physiological function—namely evaporation and heat loss. The problem therefore is how much of this adaptation is racial and how much of it is due to carbohydrate diet conserving the body fluids. The increased urine elimination of the European may have been due to his greater excretion of nitrogenous products which would be much less in the Malayan with his low protein diet. The Malayan, on the other hand, may consume more salt, which under certain circumstances promotes retention of water.

The considerations set forth above are particularly important if we are to construct a dietary suited to the climatic conditions of the tropics. Some medical men, obsessed by the idea that a good dietary must be rich in protein and fat, have advocated the wholesomeness of the protein-rich European dietary for the tropics, overlooking the fact that whole nations and working classes can develop satisfactorily and lead healthy and mentally productive lives on a diet which is almost equivalent, as far as caloric value is concerned, to the European diet but which is very poor in animal protein. It seems that dietary types like racial patterns cannot be laid down in rigid terms. The dental structure and alimentary canal of man are pre-eminently suited for a mixed diet and he is therefore probably capable of adapting himself to diets varying widely in their compositions. The determination of the minimal animal protein requirements is an interesting subject for future research and it is possible that these depend considerably on climatic considerations.

## Tropical Climate and Resistance to Infection

We have so far considered the effect of tropical climate on the individual involving chemical, physiological and psychical reactions. It would be interesting now to examine whether these changes extend to the bacterial flora of the mucous membranes of the throat, respiratory passages, the gastro-intestinal tract and other parts of the body. It is possible that climatic factors not only influence the physiological forces of the organism but also affect the pabulum on which the bacteria vegetate without in any way affecting the bacteria themselves. This brings us to the question of environment and host resistance, the importance of which from the epidemiological point of view cannot be over-rated. It seems logical enough to expect, if we accept the evidence that has already been presented regarding the alteration of the chemical, hormonic and psychical status of

the individual as a result of environmental changes, that localization of bacteria and other micro-organisms in the tissues is favoured by association with altered membrane permeability, vascular changes, metabolic alterations and ionic shifts. If these changes take place in the particular foci such as the throat and the mucous membrane of the gastro-intestinal tract, the host parasite relationship may be altered and clinical disorder may result

Infections of the gastro-intestinal tract.

There are many recorded experiments as to the effect of temperature and humidity on the resistance to gastro-intestinal infection. Arnold and his colleagues (1927–29) studied in considerable detail the effect of high temperature, especially when associated with high humidity, on the gastro-duodenal bactericidal mechanism of the dog. They showed that normal dogs exhibit a self-disinfecting power for ingested bacteria. If a living bacterial emulsion was administered by the mouth, these organisms could not be recovered from the cæcum in a viable state. When these dogs were placed in warm rooms (90–95°F. and humidity 90 per cent.) and treated in an identical manner, the bacteria ingested by mouth were passed on to the cæcum in a viable state, showing that the heat and humidity caused an interference with the bactericidal power of the dog. Again bacteria injected into the ventrally fixed duodenum of dogs placed in warm rooms soon appeared in the cæcum in large numbers. The same animals, handled in a like manner at ordinary room temperature, destroyed the bacteria before they reached the cæcum. Since in these experiments gastric acidity was excluded, one must assume that there was some other factor besides gastric acidity, or in other words, that the humid heat caused a change in the bacteriolytic action of the intestinal mucosa. In mice infected *per os* with the same dose of *Salmonella enteritidis* the fatality at a high temperature and high humidity was almost three times what would be at the same temperature but with low relative humidity.

These experiments show that high temperature associated with high humidity favoured the passage of infecting organisms across the gastro-duodenal barrier and increased the permeability of the intestine so that the bacteria could pass into the lymphatics, and finally reduced the defence of the animal to such an extent that the severity of the infection was enhanced. The fact should not be lost sight of that these experiments dealt with sudden changes of temperature and humidity. Had the experiments been conducted on animals acclimatized to a tropical climate, the results might have been different.

In attempting to correlate the experimental findings with clinical data, we are confronted with certain difficulties. It is known that enteric infections, dysenteries, diarrhœa, and colitis increase during the spring and summer months and diminish

during the winter. This increase, which is often sharp and sudden, is partly ascribable to the sudden rise in the external temperature which probably inhibits the gastric secretions and allows either infectious organisms or irritating toxic substances to pass more readily into the lower intestinal tract. Furthermore, it would appear that at a high humid temperature the intestinal tract is also more sensitive to the irritating substances produced by the normal intestinal flora. Mills (1928) in China, called attention to gastro-intestinal disturbances, associated with nausea and vomiting, following a sudden elevation in temperature and humidity. Similar effects have often been observed in India and Egypt. A sudden change to a high, humid temperature may therefore facilitate infection, or give rise to non-specific irritation. It is possible that there are certain other factors such as seasonal changes in the vitamin content of food-stuffs which are responsible for the rise and fall of resistance.

Goldwasser and Kligler (1930) studied the character of the intestinal flora of normal individuals during different months of the year under the influence of the usual diet. The number of bacteria excreted by a normal person was variable. During winter, the number of bacteria was relatively high, and cocci and anærobic spore-formers predominated, while in spring there was a transformation with a fall in the bacterial content with the coli group preponderating and cocci and spore-formers diminishing. This indicates that, associated with the sudden rise in temperature, there are changes in the intestinal tract favouring the development of saprophytic and pathogenic members of the colon-typhoid group. The cumulative data go to show, therefore, a seasonal flux in the condition of the intestinal tract of man, while the experimental results obtained with animals show to a large extent that corresponding changes are induced in them by a change from an environment with a high to one of low cooling power.

Evidence of significant changes in the physiological condition of the nose and nasopharynx in response to changes in temperature and humidity has been produced and it may well be that some of the changes are associated with a lowering of local resistance and a predisposition to cold and other respiratory infections. Cock and Mills (1932) investigated the effects of atmospheric conditions on the upper respiratory tract and found evidence to indicate that it was not only the bacteria which were responsible for the catarrhal inflammation in the respiratory tract, but environmental factors such as seasonal alterations in temperature and humidity were also important accessory factors. External temperature and humidity were important controlling factors in the incidence and death rate of lobar pneumonia. In diseases like asthma, many workers in the field have recognized the influence of climatic variations and have more than once shown the association of climatic fluctuation with asthmatic

attacks. Evidence has also accumulated which shows the seasonal fluctuations of streptococci in the throat and the severity of attacks of rheumatism and rheumatic arthritis. Wheeler, Wilson and Leask (1935) made observations on 4,857 throat cultures from 123 rheumatic children and have shown conclusively the close relationship of the pharyngeal flora with seasonal variations and the incidence of rheumatic attacks. Sharp and John (1937) have shown that carriage of hæmolytic streptococci is at a low level during the summer season and the warm climate of the Southern States of America tends to prevent or mitigate an attack of rheumatism. More information, however, is needed to prove direct correlation between environmental features and naturally occurring infections of the respiratory passages.

Radiation and resistance to infection.

It has been suggested that ultra-violet irradiation of the body, which is naturally obtainable in the tropics, has the power of increasing resistance to infections. A number of workers have demonstrated a temporary increase in the bactericidal power of the blood as the result of exposure to ultra-violet rays. This view is, however, not universally accepted. A careful study of the frequency of colds among irradiated and unirradiated groups of volunteers at Johns Hopkins Hospital has definitely shown that resistance to infection is not altered by irradiation. Similar results were obtained with rabbits injected with *Pasteurella lepiseptica*

Immunity reactions.

I do not propose here to enter into the field of immunity reactions and immune bodies in relationship to climatic changes. It is certain that the titre of immune bodies will change with the alterations in the physico-chemical status of the blood. The Report of the New York State Commission on Ventilation (1923) states that rabbits maintained at a temperature of 86°F (30°C.) showed distinctly delayed formation of hemolysins and reduced agglutinating power, as compared with control animals kept at 68°F (20°C.). It has been recently shown that in rabbits, heated so that their body temperature is raised to above 40°F (4·4°C.), agglutinins and bacteriolytic substances are produced in greater quantities than in control animals kept at room temperature. These preliminary studies indicate interesting inter-relationships and open up a new field of investigation.

Allergic manifestations.

A few words may be said about hypersensitiveness and allergy in the tropics as the phenomenon is closely associated with resistance to infection. The Indian tribes of America suffered much less from allergic diseases and were much less susceptible to experimental serum disease than the white races. Acton and Dharmendra (1933) pointed out the rarity of asthma of allergic origin amongst Indians. The reason for this lower incidence is

not known and will remain unanswered until the true nature of allergy is known. There is evidence, both experimental and clinical, that hypo-adrenia plays an important rôle in the production of allergy. It has also been claimed that slight changes in the biochemical make-up of the body might give rise to profound changes in the reactions to foreign bodies and external stimuli. It has been shown, for example, that a shift of the hydrogen-ion-concentration to the alkaline side greatly increases sensitiveness in certain tissues. I have already indicated that hypo-adrenia might well be brought about as a result of tropical heat. If this hypothesis is accepted, a higher incidence of allergy in the tropics would be expected. Apparently such is not the case. This question must be thoroughly studied before any satisfactory explanation can be offered.

## Concluding Remarks

From the survey of the effects produced by tropical environments on the physiology of the individual, certain points emerge which are worthy of further consideration and discussion. The idea that living bodies receive modifying impressions, both as regards form and quality, from the physical environment is of ancient origin and may be said to be definitely established by the experimental physiological data now available. There are, however, many lacunæ in our knowledge of the physiology of the external environment which need filling so that we may present a connected account of all these alterations in the functions of the human organism. The human organism (the microcosmos) swings in a definite rhythm with the macrocosmos (atmospheric environment). In the interplay of the meteorological rhythm with the biological rhythm of the individual, there may be synchronization, amplification, summation, or negation of effects, depending on the type and reactivity of the individual. It is conceivable, for example, that a long, thin, flaccid individual will react to an environmental feature such as atmospheric temperature, differently from a florid, stocky and strong type of individual. This brings us to the important question of 'constitution' and shows how the question of normality may be inter-related ultimately to the constitutional types. For all practical purposes, however, it is not necessary to consider such individual fluctuations and peculiarities, as many of these variations are smoothed over and neutralized when larger groups are considered. It is therefore to standardize physiological data in terms of 'normal' and 'normal ranges' that we consider groups, and not individuals.

There is great need for determining such physiological normals in the tropics. Even in such simple matters as body temperature, blood pressure, etc., the findings are not always in accord. The question of a normal standard must necessarily be

one for revision in the light of additional data and more exact technique. The differences of technique alone account for much of the difficulty in correlating earlier results on blood chemistry and blood pressure. When we are in a position to compare alterations produced in response to tropical environment, in terms of 'normals' fixed in the tropics on 'tropical' individuals, we will not only be able to understand and explain their significance more fully, but we may also be able to find out the optimum environmental conditions necessary in the tropics for the maximum development of physical and mental vigour. That environmental factors determine to a great extent the progress of mankind, Huntington has shown, and many of his conclusions have been confirmed by Mills.

The immediate effects of tropical heat and humidity on the inhabitants of cooler climates are known. Most of the physiological measurements have been recorded either on white races migrating to the tropics or at best on white settlers in the tropics. But these data cannot be used satisfactorily to explain how a native of the tropical climate would react to such variations. These records of altered physiological manifestations are no doubt useful indications of the type of variations to be expected, but any comparisons with the European figures as the standard will naturally be of doubtful value. Creditable attempts have been made by pioneer workers in the Philippines and Australia to supplement the information obtained on human races, by carefully controlled experiments on animals in artificially produced tropical environments. These animal experiments have supplied a large amount of useful data but these are also subject to the same criticism. The experiments were conducted for specified periods and though the results look quite conclusive as far as they go, they throw no light on how animals accustomed to tropical environments for generations would react to climatic changes. There is much scope for work of this kind in India with local strains of animals reared under conditions peculiar to the country.

The question of basal metabolism and the inter-related problem of optimum diet in the tropics needs further investigation even though the available data are by no means meagre. There seems to be some evidence to show that metabolism in the tropics is slightly lower than in cooler climates. As this observation fits in remarkably well with the known physiological facts regarding heat regulation in the tropics, and the diet in the tropics is predominantly rich in carbohydrates and poor in fats and proteins. European investigators are prone to lean to this view. Work in the Calcutta School of Tropical Medicine, however, has shown that there is hardly any difference in the basal metabolic rate in apparently healthy Indians (Bengalees) subsisting on an ordinary mixed diet. It is important, therefore, to re-investigate the problem and to see whether any racial

factor is involved in it. Intimately associated with the question of basal metabolism is the question of the functional activity of the endocrines. There is some evidence to show that tropical environments depress the thyroid-adrenal apparatus as well as the gonads, and the sluggish metabolism, the lower energy rate, the earlier onset of the menopause and the supposed lowering of host resistance are only expressions of this endocrine dysfunction and inadequacy. Here lies an aspect of physiology which should attract young scientists. While some observations by histopathological and histochemical methods on the colloid content of the thyroid gland and the presence or absence of 'granules' in the cortex and medulla of the suprarenals have been recorded as evidence of their altered function, and while quite a large volume of work indicating the active participation of the supra-renal glands in the process of 'chilling' have emanated from the laboratories of Prof. Cannon of the Harvard University, there is as yet no definite and direct proof of this endocrine insufficiency or dysfunction under tropical environments. No satisfactory method exists for estimating the amount of adrenalin in the circulating blood and body fluids. If such a method can be devised and the technique perfected, it will be a distinct advance in the study of the activity of the endocrine functions in individuals living under different climatic environments, and in correlating this activity with increased or decreased metabolism, increased or decreased resistance to infections, increased or decreased somatic reflexes and psychical status of individuals. It has been reported that the incidence of metabolic diseases, *viz.* diabetes, exophthalmic goitre, and Addison's disease, pernicious anæmia, angina pectoris, chronic nephritis, etc. are lower in the tropics than in the temperate zones, while on the other hand, the infectious diseases generally are more common. It is also a general belief that sexual maturity is gained earlier in the tropics than in cooler climates. Recent researches, however, tend to indicate that the reverse is probably true. Much useful work could be done in this connection in India. It is probable that the final answer to these and to many such conflicting hypotheses will be found through a study of the endocrine inter-relationships. In presenting this subject, I realize more than anybody else, the complexities of the task and the limits of the undertaking that I have set upon myself. On going through the literature on the subject, one is forcibly struck with the extremes of opinion held and the disparities in the observed and recorded facts regarding the various responses of the body to climatic changes. The reason for these differences is not far to seek. The study of this aspect of physiology presents inherent difficulties, as here, unlike that of other problems one has to analyze carefully the innumerable possibilities entailed by the interaction of two highly dynamic systems, *viz.* the atmospheric environment with its constant fluctuations and

'pulsations' due to cyclonic circulation and temperature changes of the incident solar energy, on the one hand, and the human individual, that integrated cell mass in a state of dynamic equilibrium with his internal environment, on the other. The study of the physiological basis of the effect of climate on the individual shows that he is fashioning his own evolution by struggling to adapt himself to his climatic environment. This adjustment is brought about by three major components of the autonomic apparatus—chemical, hormonal and nervous. We have to study all these systems in all their various phases and ramifications, correlate all the disjointed observations in logical sequence and fit them into a perfect mosaic. Only then can we hope to project a picture, complete in all its details of the phenomena of biological adaptation of the organism to its environment, as exemplified in the process of acclimatization—individual or racial—of human beings in the tropics. In modern medicine and physiology, a consideration of the environmental influence has been relegated to the background for it has been thought that all acute infectious processes and normal physiological events run a comparatively steady course, uninfluenced by environmental factors. Enough scientific evidence is now available, some of which has been discussed already, which leaves little room for doubt that environmental factors are important forces to be reckoned with that if these are studied in greater detail, particularly with reference to the changes that they might produce in the human organism, a new branch of physiology may be developed in this country. The material is in abundance; but it needs the sickle of properly organized and directed research to garner a harvest which will be of the greatest value to us in India as well as to the world at large.

# SECTION OF PSYCHOLOGY

*President* :—G. Bose, D.Sc., M.B., F.N.I.

# *Presidential Address*

## AMBIVALENCE

### Negativism

The mental phenomena which go by the name of negativism have been the subject of study by psychiatrists and psychologists for a long time past. Negativistic mental states are to be observed both in normal and abnormal persons. Young children very often show such traits. In normal adults also negativism is pretty commonly seen. It is however in certain types of dementia praecox that negativism attains a pathological development and becomes so prominent that it draws the attention of even the most superficial observer. These patients often do the exact opposite of what is demanded of them. In some instances it is possible to control them and make them follow a required course of action by asking them to do the opposite.

Negativism is to be noticed not only in the sphere of action but also in thought processes and affective manifestations. The same perception, for instance, evokes contradictory judgements and is invested with opposite feelings. Sometimes it is only the negative phase that becomes prominent and on other occasions a compromise between the opposing tendencies becomes manifest.

### Bleuler's Concept of Ambivalence

No satisfactory explanation of negativism has yet been forthcoming. Bleuler in critically examining the views of Raggi and Paulhan (1887), Gross (1902), Lundborg (1902), Vogt (1903), Hoche (1904), Schüle (1904), Anton (1904), Alter (1904), Sante de Sanctis (1904), Dromard (1906), Kraepelin (1909) and others came to the conclusion that none of the theories offered by these different workers could satisfactorily meet the varied manifestations of negativism. Bleuler thought that the predisposing causes of negativistic phenomena are—

(1) ambitendency which sets free with every tendency a counter tendency,

(2) ambivalency which gives to the same idea two contrary feeling tones and invests the same thought simultaneously with both a positive and a negative character,

(3) an upsetting of the normal balance of these opposing and co-operating psychisms, and
(4) lack of clearness of logic in patient's thoughts.

Bleuler further believed that these patients live a life of phantasy and every influence acting from without is taken as an intolerable interruption to face which the negativistic attitude, which forms a component of ambivalence, is brought into prominence. The patient suffers from a sense of hurt which must be protected from contacts. The surroundings are looked upon as hostile by the patient. Bleuler said that sexuality with its ambivalent feeling tone is also often one of the roots of negativistic reaction and that " very pronounced phenomena of negativism affecting judgements and feelings have probably often other co-operating causes which we do not know " ; a conclusive explanation of all negativistic phenomena would be premature.

It seems that to explain negativism Bleuler conceived of an innate ambivalence in the human psyche. This ambivalence is something fundamental and cannot be further analysed. Bleuler stopped by merely stating that counter tendencies exist. He did not try to analyse their nature. What Bleuler meant by the two terms ambitendency and ambivalency is included at the present day in the single term ambivalence.

### Freud's Views on Ambivalence

Bleuler's concept of ambivalence, simple though it is, has thrown a flood of light on many obscure mental reactions. Ambivalence as a fundamental mental trait has been accepted by almost all psychiatrists and psycho-analysts. Freud utilized this concept in his psycho-analytic interpretations especially in elucidating the relationship between love and hate. Since the time of Bleuler he has been the only person to make an endeavour to probe deeper into the problem. Unfortunately Freud's analysis of ambivalence has not been very fruitful. He is sometimes inclined to consider ambivalence as a fundamental trait of mental life and sometimes he thinks that it may be a derivative of some other process. Freud writes ('Totem and Taboo', pp. 258), " We know nothing about the origin of this ambivalence. It may be assumed to be a fundamental phenomenon of our emotional life. But the other possibility seems to me to be worthy of consideration ; that ambivalence, originally foreign to our emotional life, was acquired by mankind from the father-complex, where psycho-analytic investigation of the individual today still reveals the strongest expression of it." Freud in his paper on 'Instincts and their Vicissitudes' suggested the theory that an instinct is built up by a successive welding of active and passive elements and that it is this that gives it the character of ambivalence. In the same paper Freud

has discussed how an active phase of an instinct undergoes reversal into its opposite and is turned round upon the subject. The reversal affects not only activity and passivity, but also the emotional tone, or the content as Freud describes it, so that love is changed into hate. At one stage in this reversal, the original object of the instinct is abandoned and is replaced by the subject's self. This is made possible by the inherent narcissism of the ego and presumably the ego's tendency to identification. In his book 'Group Psychology and the Analysis of the Ego' Freud says, "Identification is ambivalent from the very first; it can turn into an expression of tenderness as easily as into a wish for some one's removal. It behaves like a derivative of the first oral phase of the organization of the libido in which the object that we long for and prize is assimilated by eating and is in that way annihilated as such." According to Freud the unconscious hostile feeling of the child towards the father is traceable to this mechanism.

The theory of superimposed opposite components of an instinct does not carry us very far. The main factor responsible for the ambivalence seen in introjection and identification is the functioning of the oral libido which from its very nature loves and destroys at the same time. Oral libido as a causative factor in ambivalence is the most important contribution of Freud in this line. The assumption that oral libido will explain all cases of ambivalence is not warranted by facts and Freud himself has never specifically maintained this proposition.

## The Unconscious Factor in Ambivalence

There is an aspect of ambivalence which has not been properly stressed. Opposite types of behaviour under different situations or at different times are quite common among normal people and have never been sought to be explained by the theory of ambivalence; pure negativism would not call for a supposition of ambivalence either. It is only when opposite tendencies are observed working simultaneously and affecting behaviour that some explanation like that by ambivalence becomes necessary. A person who never listens to a command and does only the opposite of what is asked of him, is perhaps harbouring a feeling of defiance, but if such a person shows habitually a compromise reaction where both positive and negative traits are observable simultaneously, we are justified in bringing in the theory of ambivalence to explain his behaviour. A child may be loving its father today and hating him tomorrow quite consciously. Such alternation of behaviour is not necessarily an instance of ambivalence as we understand by that term. The child might have been chastised by the parent and the feeling of hostility might have been a temporary one and might be effaced by the kind behaviour of the father the next day.

Opposite tendencies and opposite feeling tones, it is true, cannot appear in consciousness together. There is however nothing to prevent them from emerging into consciousness alternately. Such alternation may be very rapid as for instance when a person is hesitating whether to do an act or not. Hesitation is not an ambivalent behaviour. In hesitation the conflict is in the conscious level. In true ambivalence, opposite tendencies are supposed to be present, but one of the contending elements at any particular moment must necessarily be unconscious. When a dementia praecox patient stretches out his hand to receive something and yet at the same time keeps his palm down and further shows no evidence of hostility or defiance, it is only then that ambivalence is supposed to be at work. Because of its unconscious element ambivalence is never a matter of direct observation ; it is to be regarded as an explanatory concept. It is true that under certain conditions the originally unconscious opposite tendency may come into consciousness. Under such circumstances it generally pushes its previous conscious counterpart into the unconscious so that ambivalence persists. I would therefore define ambivalence as a simultaneous working of opposite tendencies, one of which remains unconscious.

### Ambivalence in Feeling, Emotion and Judgement

Besides expressing itself in opposite tendencies, ambivalence is manifested in connection with pleasantness and unpleasantness, in emotional states such as love and hate, and in opposite judgements. When we say that a child's attitude towards his father is ambivalent, we do not mean that he sometimes hates him and sometimes loves him, but that his behaviour towards his father is to be interpreted as a conscious love-reaction mixed up with an unconscious hate-reaction or *vice versa*. In such cases the conscious emotion attached to the act is either one of love or one of hate. It is usually assumed by psycho-analysts that the male child loves his father because of his affectionate behaviour and hates him because of his unconscious Oedipus rivalry. This hate, remaining unconscious affects the conscious love and makes the emotion ambivalent. It is further assumed that hate is as much an independent emotion as love and that its origin antedates that of love genetically.

The hate-reaction, as a psycho-analyst understands it, is an anomaly. Is there such a thing as an instinct of hate? Freud in his paper on 'Instincts and their Vicissitudes' says, "We might at a pinch say of an instinct that it 'loves' the objects after which it strives for purposes of satisfaction, but to say that it 'hates' an object strikes us as odd." Freud assumes that hate is a reaction of the ego against painful surroundings. "The ego hates, abhors and pursues with intent to destroy all objects which are for it a source of painful feelings, without

taking into account whether they mean to it frustration of sexual satisfaction or of gratification of the needs of self-preservation." On the other hand "Love originates in the capacity of the ego to satisfy some of its instincts auto-erotically through the obtaining of 'organ pleasure'." "It is primarily narcissistic, is then transferred to these objects which have been incorporated in the ego, now much extended and expresses the motor striving of the ego after these objects as sources of pleasure." The oral libido which loves and destroys at the same time is one of the earliest forms of love. Freud says, "This form and preliminary stage of love is hardly to be distinguished from hate in its behaviour towards the object. Only when the genital organization is established does love become the antithesis of hate." "The sexual and ego-instincts readily develop an antithesis which repeats that of love and hate." The ambivalence of love is to be traced to the admixture of hate derived from the self-preservative instincts. In the sadistic anal-erotic stage of libido development, the sexual function is governed by the ego-instincts to some extent. Thus hate and love get mixed up.

In his later writings, Freud has correlated hate and sadism with death-instinct which stands in contradistinction from love-instinct or Eros. The antithesis therefore, according to the newer view, exists not between self-preservative or ego and love-instincts, but between love and death instincts. I have not mentioned the rôle of death-instinct in ambivalence, because whatever I have said about Freud's older conception of the antithesis between ego and love-instincts, holds true *ipso facto* about death and love instincts. Freud has mixed up the emotion of hate with the desire to kill. Emotion and wish have both been invested with motive power for action. This idea of alliance of wish and emotion is at the root of the statement that there exists an antithesis between love and hate. Freud is thus led into an anomalous situation and has to admit that in the early stages of libido development "love is hardly to be distinguished from hate."

To ascribe ambivalence to love is therefore not a sound proposition. Of course, the question 'When does hate appear instead of love in a particular wish situation or *vice versa*' is a pertinent one. So also the problem of arousal of pleasantness and unpleasantness in an act. If we assumed wish to be the motive force of behaviour, it would be easy to prove that behind the emotional states of love and hate are wishes of opposite types, so that the real opposition between love and hate lies in the contents of the corresponding wish situations. I have also shown elsewhere that perceptions are determined by action attitudes, in fact the meaning of a perception lies in the action attitude it provokes, and an action attitude is to be interpreted as a latent wish, so that even in the domain of perception and judgement opposite tendencies may be discernible. Therefore if

we assumed that ambivalence affects only the wish, it would be quite sufficient for our purpose. We would not discuss the opposition between love and hate as such in ambivalence but we must consider the opposition between the wishes that lie behind love and hate. We shall not be discussing the ambivalence in judgements, but the ambivalence that lies between the different action attitudes which determine those judgements and so on. The problem of ambivalence is therefore restricted to the domain of wish only. This restriction of connotation of the term ambivalence is not an arbitrary one, but is based on sound psychological principles. This would be the first step towards understanding the genesis of ambivalence. What I mean by the term wish and why I consider that wishes alone provide the motive force of our activities and that emotions and feelings, apart from their wish elements, are not to be held as incitors of actions I have discussed in a previous paper entitled 'A New Theory of Mental Life', Indian Journal of Psychology, Vol. VIII, Nos. 1, 2 and 3, 1933.

Let us probe deeper into the mechanism of the so-called opposition between love and hate. It is only in the domain of a dynamic entity that the concept of opposition holds good. If we are to recognize an opposition between such elements as pleasure and pain, love and hate, subject and object as has been done by Freud, we must suppose that these entities are of the dynamic order. As I have indicated before, whatever dynamism exists in these psychical entities, is to be traced to the action attitude in each. Pleasure and pain are opposites because they are usually associated with opposite types of reactions, otherwise they are just like any two different experiences, e.g., red and green colours. If we did not invest red and green with opposite action attitudes, we would not consider them to be opposites, they would be merely taken as different experiences. In the case of opposition between active and passive wishes, the opposite action attitudes are on the surface and need no analysis for appreciation. When we posit an opposition between love and hate, we fail to note that what we call love or hate are usually complex situations made up of wishes, feelings and emotions. Love-wish is not the same thing as love-emotion. The opposition is to be sought for in the domain of love-wish and hate-wish and not in love-emotion and hate-emotion or pleasure and pain.

For all analytical purposes, it will be desirable to separate the wish from its emotional and feeling attachments and to concentrate our attention on the dynamic factor only. What I have said here will be best understood by examples. The act of killing or destroying is often associated with the emotion of hate and it is quite easy to confuse the wish to destroy with the emotion of hate. If we remember that only wishes provide the motive force of action and that the emotions and feelings are

more or less like epiphenomena then we shall avoid such pitfalls. I may destroy an attacking snake with the emotion of hate and throw it away with hate or disgust. Again, if I happen to be a head-hunter, I may kill my enemy with hate and preserve his skull with pleasure, or again I might kill a lamb with indifference or even pity and eat the flesh with pleasure. The act of destruction itself may also be pleasurable as for instance I may cut up a mango or dress meat with feelings of pleasure, sometimes almost with an emotion of love, and eat the mango or the meat also with love or pleasure. Freud made a jocose remark that the cannibal has a 'devouring love' for his enemy. Here the hostile act and the love act are identical and the wishes that lie behind these acts are the same. So the wish to destroy may be either a love-wish or a hate-wish and when such is the case one need not posit an opposition between love and hate.

Then again love and hate may show identical reaction-situations. In hate-situations the old Mosaic Law—'Eye for Eye, Tooth for Tooth'—holds good. The retaliation reverses the subject-object relation. In love reactions also the same sort of reversal of the subject-object relation takes place. A kiss evokes a counter-kiss just as a blow evokes a counter-blow. In the retaliatory reaction the predominant emotion tone is hate, whereas in love-reciprocity the emotion of love colours the reaction. There is no fundamental difference between the two types of reactions. In fact, one might with perfect justification say in certain situations, 'I would love to kill my enemy.' Revenge may certainly be sweet.

Similarly pleasure and pain are opposites only when they evoke opposite types of activities, otherwise they may be considered as two different experiences. The same act may be pleasurable today and painful tomorrow. A child would tear a living bird to pieces with great glee whereas an average adult would feel pain even in contemplating such an act. Just as there need not be an opposition between a love act and a hate act, so there need not be an opposition between a pleasurable act and a painful act. The arousal of pleasure or pain, love or hate depends on many factors. Feelings and emotions of any specific type are not inherent in specific acts. Neither can pleasurable and painful wishes nor love and hate wishes be listed under two separate classes. The same wish may be invested with either love or hate, pleasure or pain. So the antitheses between pleasure and pain and love and hate do not really exist. When an opposition is present at all it is traceable to different action attitudes and is independent of the affect.

## Is Ambivalence a Characteristic of a Single Wish or a Pair of Opposite Wishes ?

Since the opposition is to be noted only in the domain of wish, the genesis of ambivalence is to be looked for in the mecha-

nism of opposition of wishes and the process by which one of the contending pair becomes unconscious. It would be wrong to speak of an ambivalent wish in the singular unless we considered that it is the same wish that is capable of being directed both towards the subject and towards the object, so that at one time the wish would be of the active type and at another it would be passive and again at one time it would be directed towards an external object in its effort at fulfilment and at another it will take up the self as its object. In fact this is the view that has been accepted by Freud and other psycho-analysts and from this standpoint the term ambivalent wish is not a misnomer. Masochism is according to this view nothing but sadism turned against the self. The wish in both the situations is the same.

If, however, we consider an active and a passive wish to be entirely different from each other, ambivalence should be traced to the opposition between the two and the preponderance of the one or the other in consciousness. Acting separately neither sadism nor masochism would be ambivalent, but the ambivalency is to be traced to their mutual conflict. It is the pair composed of sadism and masochism that shows ambivalence. The unconsciousness attached to one of the components of the ambivalent pair could very well be a matter for further psychological investigation and analysis just like the unconsciousness attached to a repressed wish. The difference between an unconscious repressed wish of the ordinary type and the unconscious component of the ambivalent pair need not be a fundamental one. Apparently, where ambivalence is concerned, the conscious behaviour would be exactly opposite to the repressed one, whereas in ordinary repression according to the usually accepted view, this is not necessarily so.

For a biologist who is not concerned with the mental attitudes of organisms and to whom all individuals of a species are more or less alike, there is no necessity of drawing a distinction between the subject and the object. When an animal bites another of the same species the biologist concentrates his interest on the act of biting. It is true that the activity of the aggressor and the passivity of the aggressed may draw his attention but he does not care whether the animal *A* attacks *B* or the animal *B* attacks *A*. The two situations appear identical to him for the purposes of his science. Thus he has no need to distinguish between such pairs of opposite wishes as sadism and masochism. He can with perfect justice say that there is only a single instinct in connection with the act of aggression and that it is not necessary to distinguish between the aggressor and the aggressed in the operations of the instinct of aggression. When an individual is playing the rôle of the aggressor, the instinct is directed towards the aggressed and when he is the aggressed party it is the same instinct directed towards him. There is no doubt that Freud's conception of sadism and maso-

chism and his idea of the turning round and reversal of an instinct are more biological than psychological.

It must be noted that even in a passive wish situation there is an element of activity, e.g., in a love situation one actively desires to be kissed. Similarly, in masochism the subject actively wants certain situations of the passive type. The single instinct of aggression will not explain the desire to be aggressed which is the special characteristic of masochism. From the psychological standpoint, therefore, we are bound to assume the existence of distinct and separate active and passive wishes, in situations like those of sadism and masochism. No amount of sadism directed against the self will make it masochism until the individual willingly submits to the aggression. Directly he does so, we are bound to assume an independent passive wish wanting to be fulfilled under definite conditions.

One may submit unwillingly to a painful situation as a matter of necessity but this is not the same thing as the desire to be aggressed. Further, the theory of reversal of instincts cuts both ways so that instead of looking upon sadism as primary and masochism as sadism directed against the self, we might say that masochism is primary and sadism is only masochism transferred to the object. It is to meet such objections that Freud had to assume successive layers of active and passive wishes in the make-up of an instinct. Introspective evidence will fully bear out the fact that such active and passive wishes, although related to one another in certain ways, are quite independent by themselves and there is no reason to suppose that the one group is more important than the other. Pathological manifestations and psycho-analytic evidence are also in favour of the separate and independent existence of active and passive wishes. In fact, in his later writings Freud had to modify his views and assume a primary masochism (Freud—Collected Papers—Vol. II, pp. 255–268; 'The Economic problem in Masochism. Beyond the Pleasure Principle', p. 70) It is thus seen that neither the theory of admixture of eros and death instinct nor the theory of the turning round and reversal of an instinct really explains ambivalence. So long as we are forced to admit the independence of active and passive wishes and so long as we are not in a position to show the relationship between the contending elements we shall not make any advance on the theory of ambivalence put forward by Bleuler.

## Active and Passive Wishes

The human mind is capable of developing both active and passive wishes. The desire to kiss and the desire to be kissed may both be experienced by a subject and both the acts may be pleasurable. There is no reason to suppose that the active wish gives more pleasure than the passive one or *vice versa*. Some of

the active and passive wishes can be arranged in pairs of opposites, e.g., the desire to kiss and be kissed ; pay and expect a visit and so on. It will be noticed that such pairs of opposite wishes are to be found mostly in the domain of love and social life, *i.e.*, where we have dealings with other sentient fellow beings. In connection with inanimate objects, corresponding active and passive wishes are not observed, e.g., the desire to eat a mango may be present but not its passive counterpart, *viz.*, the desire to be eaten by a mango. In fact the passive counterpart is something impossible of attainment here. The desire to kill a tiger has as its passive counterpart the desire to be killed by the tiger. The possibility of the event corresponding to this type of passive desire is present. Tigers do kill men but one never comes across the desire to be killed by a tiger in actual life except perhaps in a suicide who chooses this particular mode of ending his existence. Under ordinary conditions this passive situation appears in consciousness not as a desire to be killed but as a fear of being killed. I shall have to say something more about paired wishes presently.

### Subject-Object Antithesis

Neither the antithesis between love and hate nor that between activity and passivity gives us any clue to the solution of ambivalence. I shall now take up the question of subject-object antithesis. The polarity of subject and object has been an eternal problem with the philosophers. Leaving all philosophical speculations aside, I shall try to analyse the subject-object relationship from the psychological standpoint. It will be advantageous at this stage to limit ourselves to wish situations where the object is a sentient and reciprocating individual. Let us suppose that *A* feels a wish to make a monetary gift to *B* who is willing to accept it. Such a wish situation demands that *A* must have some conception of *B*'s needs before the desire to help him arises in his mind. When we realize the sufferings or exaltation or in fact any other characteristic of another person, we unconsciously place ourselves in his position. It is thus by the mechanism of identity that *A* is able to realize *B*'s position. In identity a part of the ego is thrown out as it were and gets itself attached to the object. It is by means of this bond that we appreciate that the person is desirous of receiving some help. Identity enables us to divine the wishes of a sentient being who is similar to us. In the wish situation under discussion the portion of the ego that is thrown out and is able to effect identification, feels like the object, *i.e.*, it wants to receive something through the object. We may call this portion of the ego the objective half of the ego or simply the objective ego. It is really a portion of the original ego. The original ego splits up into two. The portion which feels the

subjective wish, *i.e.*, the desire to make a gift, in the illustration under consideration, may be termed the subjective half in contradistinction to that part which effects the identification and in a way feels the wishes of the object and which I have just termed the objective half. It will be noticed that the subjective ego feels the desire to make a gift whereas the objective half feels the desire to receive the gift. This latter wish remains more or less unconscious and is foisted off on the object who is looked upon as a person willing to receive a gift. To make a gift and to receive a gift are quite opposite tendencies and it may be assumed that the original ego in coming into contact with an object and in trying to realize its characteristics, splits up into a subjective and an objective half, one of which feels the stress of an active wish and the other that of a passive one. The active and the passive wish form a pair just like sadism and masochism in ambivalence. The resemblance goes further. Just as in ambivalence one of the components of the pair is unconscious so here also the objective half of the ego acts in an unconscious manner.

### Secondary Ego

To ascribe a wish to the projected objective ego is not a mere theoretical necessity. Under certain situations, objective wishes may be consciously felt as for instance in empathy. In Vaishnav literature, one comes across an interesting episode regarding Radha, the consort of Krishna. Radha feels bitterly the absence of Krishna for some time and then imagines herself to be Krishna seeking Radha. Certain paraphrenics complain of the curious symptom that directly they come into contact with any object and want to grasp the nature of it, the feeling comes to them that they are one with the object, so that the contemplated action becomes an impossibility and they want to have the exact reverse done to them. One of my patients told me that whenever he wanted to bow down before the God Siva, he became Siva himself and demanded homage. Sitting opposite to me during the analytical hour he would often ask me to give him my associations. When questioned about the strange behaviour, he said that whenever he tried to concentrate on what I was saying, he felt that the situation was reversed and that he was the doctor and I the patient. It would appear that in such cases, the original ego transferred itself to the site of the object and behaved as a secondary ego from the standpoint of the original object and felt the objective cravings consciously; the striving of the original subjective half became unconscious.

We might push the analysis a little bit further. In the gift illustration there is no disturbance of the contemplated action, whereas in the case of Radha and in that of the paraphrenic patient, the originally contemplated act is disturbed. It thus

seems that under certain conditions, the unconscious wish belonging to the objective ego sets up an opposition against its subjective counterpart and in becoming conscious as a secondary ego pushes its antagonist into the unconscious level. It then sways the original ego and makes it behave according to its dictates reversing the original subject-object relation. There is an inherent opposition between the subjective and objective halves of the ego. This opposition is the psychological prototype of the eternal antithesis between the subject and the object. It is a fundamental opposition and includes within it the opposition between activity and passivity. In fact, it is the most perfect opposition conceivable. Mere turning round does not explain this opposition or reversal nor does subsequent choice of a new object by the primary ego as has been supposed by Freud. We must assume a secondary ego taking up the position of the original object and pairs of opposite wishes in the original ego corresponding to the subject-object relationship before we could explain the curious behaviour of Radha and the paraphrenic and the change from sadism to masochism.

### Opposite Wishes

In view of the perfect opposition existing between the subjective and the objective halves of the ego, it is a wonder that a wish situation comes to be fulfilled at all. As a matter of fact in unimpeded actions, the objective ego's wish is not consciously realized and is not felt as the subject's striving. As I have already said it is foisted into the object and serves to bring the position of the object prominently before the ego. The subjective striving is satisfied directly whereas its objective counterpart finds unconscious gratification in the realization of the object's position during the act. Hence all conflict is avoided and the entire action is invested with a pleasurable tone.

We might assume that pairs of active and passive wishes of all sorts exist in the psyche; the component wishes forming each pair are exact counterparts of each other, *i.e.*, they correspond to the specific subject-object situations. Ordinarily the wishes inhibit each other and the ego remains in a neutral state free from apparent strain. Under certain conditions, in the presence of an object, the ego's equilibrium is disturbed and the wish corresponding to the objective situation is thrown out by the ego as a pseudopodium, to borrow a biological analogy, and it invests the object. The subjective counterpart of the wish is felt by the ego as a striving towards the object. When the act is completed, the subjective striving finds satisfaction at the situation of the main ego and the objective striving at the situation of the object carried there, so to say, by the pseudopodium. Sometimes, as for instance in the case of the paraphrenic mentioned before, it seems as if the pseudopodium

became the principal ego and the striving in that situation is felt as a conscious wish. This is the process of the formation of what I have described before as the secondary ego. Whenever the ego thinks in terms of the object, it may be described to be functioning as the secondary ego, the primary situation being then treated as a secondary object situation. This is complete reversal of the original situation.

In dealing with inanimate objects the objective striving is seldom felt as a conscious wish. Hence in situations where no reciprocity is possible we do not usually notice the formation of a pair of opposite wishes. In paraphrenics the objective striving, even with inanimate objects, is sometimes apparent. My patient said that when he came before a tree, he became the tree himself. This delusion is really a manifestation of the wish to become a tree. Opposite pairs of wishes may therefore be supposed to exist in all possible wish situations. It is only where reciprocity is possible that the components of the pair become manifest sometimes as an active and sometimes as a passive wish. When the objective half of the ego can transfer itself without impediment to an external object, there is no struggle and the conscious subjective striving becomes a pleasant one. When, however, the transference of the objective half is not perfect, struggle within the psyche is inevitable during the fulfilment of the subjective conscious wish and the act becomes painful. It is under such circumstances that hate, disgust, pain and other unpleasant experiences arise and ambivalence develops.

### Repression

My view is that if there is an one-sided influence in childhood favouring the satisfaction of only one of the pair of opposite wishes, repression results ; if for instance a child is constantly allowed to have its own way in everything and is never made to feel any restraint, its sadistic wishes will have more opportunities for actual satisfaction than its masochistic ones. The 'channels' for sadistic discharge will develop at the expense of the masochistic outlet so that after a time, the accumulated tension of latent masochism becomes a disturbing factor and its channel of discharge being ill-developed, its mobility suffers. In a sadistic act the objective half of the ego plays the masochistic rôle. If the masochistic objective half is ill-developed and cannot be transferred to the objective situation, the sadistic act itself loses its pleasurable tone and shows signs of masochistic compromise or in other words ambivalence develops. It is repressed masochism that makes sadism ambivalent and *vice versa.* So with all other pairs of opposite wishes. The rôle of the opposite wish with an ill-developed channel of discharge is the same as that of any other repressed wish. My idea is that the prime force of repression of any wish is derived from its opposite

counterpart. Sadism represses masochism and *vice versa*; active homosexuality represses passive homosexuality and *vice versa*; the desire to play the mother's sexual rôle represses the child's Oedipus cravings and so on. I have discussed the whole question of repression in detail elsewhere ('Concept of Repression and New Theory of Mental Life') and need not go into it again.

### Paired Wishes

We may now revert to the question of opposition in paired wishes. From the standpoint of action attitude wishes may be broadly classed under two heads, *viz.*, active and passive. If we examine the nature of active and passive wishes with reference to their object choice we find, as I have already pointed out before, that some of them correspond to one another in a very striking way, e.g., the active wish to kiss a loved person has its exact counterpart in the passive wish to be kissed by that person. In the two situations the subject-object relations stand reversed. Such corresponding active and passive wishes are related to each other in certain definite ways. The action attitudes of two such corresponding wishes being exact opposites they cannot obviously arise in consciousness simultaneously. The verbal expressions corresponding to the two opposite action attitudes however, when divested of their cathexis, may both be conscious at the same time. There is a regular sequence of arousals of these opposite wishes. The satisfaction of one invariably gives rise to the conscious demand for the other. In kissing we expect to be kissed in return and in being kissed we return the kiss. Unless both the active and passive acts are gone through a feeling of incompleteness and tension persists. This is traceable to the operations of the unsatisfied wish. Such corresponding active and passive wishes are thus seen to be more or less inseparable and to form pairs. We might say that satisfaction, whether voluntary or involuntary, of one of the pair serves as a stimulus to the arousal of the other in consciousness. Such pairs of active and passive wishes are, as I have already mentioned, generally to be found in our dealings with other sentient individuals of our own species, *i.e.*, in love and social intercourse.

If, instead of confining our attention to the subject only in such wish situations, we take into consideration the reactions of the sentient object also we find that they follow a certain definite law. The same active and passive wishes of the pair that we find in the subject are in operation here also but with a reversed sequence. In being kissed the object also returns the kiss and in being asked to kiss expects a return kiss. It is thus that a kiss evokes a counter-kiss, a blow evokes a counter-blow. This is the mechanism of all reciprocal and retaliatory actions. The law that governs such actions is the Mosaic Law,

## IDENTIFICATION

The presence of such opposite pairs of wishes both in the subject and in the sentient object leads to the formation of a special bond between them. The subject can easily appreciate the position and behaviour of the object in an act of this type. During kissing for instance the subject's desire to be kissed remains latent and it is this latent desire that enables him to realize the position and characteristics of the object who is also invested with the same desire. The subject's latent counter-wish is supposed to be the conscious wish of the reciprocating object. To revert to my previous description it is the objective half of the ego that feels the latent counter-wish and this is the bond of identification of the main ego with the object. Once the bond of connection is established the ego can transfer itself in its entirety to the object's position and behave as a secondary ego. In the first stage of identification, *i.e.*, when the objective half of the ego only is transferred to the position of the object the latter's willing participation in the act is realized ; the subject knows that the object feels pleasure in being kissed. At the next stage when the secondary ego is formed, *i.e.*, when the entire ego can completely go over to the object's position the subject appreciates the latter's reciprocating tendency ; there is complete identification. If the subject's original rôle is passive, as in early infancy, reciprocating reaction is the first to be established. In being kissed the child returns the kiss without having any sympathetic understanding of the object. This phenomenon is what I have designated elsewhere as action identity. Action identity is the basis of imitation. Action identity enables the child to realize the position of the active object and this is the bond which the developing secondary ego of the child utilizes to go over to the position of the object and effect complete identification or ego-identity as I have called it.

Under normal conditions the functioning of the secondary ego goes on more or less unconsciously and it is through this process that the ego expands and acquires fresh knowledge of men and things. The secondary ego may under exceptional conditions become fully conscious and can replace the primary ego as in the case of the paraphrenic mentioned before. In self-punishment and similar acts the secondary ego acts as the subject. It derives its motive force from the latent counter-wish of the primary ego.

## THE WISH CIRCUIT

To explain reciprocal and retaliatory actions in the adult we have to assume ready formed pairs of opposite active and passive wishes within the psyche. These contradictory wishes inhibit each other and a state of equilibrium is maintained.

Under certain conditions which I need not discuss here one of the pair becomes prominent and appears as a conscious wish with reference to a special object. As soon as this conscious element of the pair finds satisfaction its inhibiting force is removed and its opposite counterpart springs to consciousness as an urge for a reciprocal or retaliatory act directed against the object. In all actions where opposite pairs of wishes come into play and where there is no repression the latent element of the pair throws out the bond of identification with the object making it possible for the entire ego to traverse this bond as a secondary ego and to establish itself at the objective point of the wish situation or the wish circuit as I have called it. A complete wish situation of this type therefore carries with it two pairs of opposite action attitudes, one at the subjective point and the other at the objective end. To come to our illustration, at the subjective end the conscious or the subjective half of the ego feels the active striving to kiss; at this point the objective half of the ego has the latent desire to be kissed. In establishing itself at the objective end the secondary ego looks at the original subject as the object for its strivings. The subject thus becomes the secondary object with reference to the secondary ego. The secondary ego also feels the urge of a pair of opposite wishes like the primary ego with this difference that its subjective half has a passive desire to be kissed by the original subject and its objective half has the wish to kiss him actively. This last wish is really the determinant of the reciprocal action on the part of the real object. If we name the subject and the object *A* and *B* respectively and if we assume that all the situations in the wish circuit are conscious we may summarize by saying that at the primary subjective position *A* feels the active desire to kiss *B*, at the secondary subjective situation *A* feels that *B* has the passive desire to be kissed by *A*, at the secondary objective situation *A* feels that *B* has the desire to kiss *A* actively and lastly at the primary objective situation *A* feels the desire to be kissed by *B*.

At the secondary subjective situation there is partial identity of the subject with the object, at the secondary objective situation the identity is complete; the subject has projected himself completely into the object's position and at the primary objective situation there is a complete reversal, in the Freudian sense, of the original craving. Ordinarily only the primary subjective position is conscious but the normal person can realize all the different situations of the wish circuit if he wants to. Under special conditions of repression any of these four situations may become prominent in consciousness to the detriment of the others. When the primary subjective position is conscious, *viz.*, *A*'s wish to kiss *B* in our example, it is considered a normal wish if there is some sort of realization of the other three situations. Where there is no such realization *A*'s wish

is considered to be a selfish one as consideration for the other party *B*, who is the object, is lacking. When the secondary subjective position only is conscious, *i.e.*, when *A* thinks that *B* wants to be kissed by him the behaviour is an abnormal one; here *A* wants to shift the responsibility of his own action to *B*; it is akin to the plea—'the woman tempted me'. When the secondary objective phase only is conscious, *i.e.*, when *A* feels that *B* wants to kiss him the situation is exactly like that of paranoic projection. Lastly, when the primary objective phase only is conscious, *i.e.*, when *A* feels that he wants to be kissed by *B* the situation corresponds to the complete reversal of the original wish. It is like the conversion of sadism into masochism. All the three subsequent situations in the wish circuit are repression products and invariably show signs of conflict with the original primary subjective situation. The conflict is most acute between the first and the fourth phases, *i.e.*, the desire to kiss *B* and the desire to be kissed by *B*. Whenever there is any conflict the pleasure that should normally arise in the fulfilment of a wish is impaired either partially or completely and in its place pain and unpleasant affects make their appearance. For instance, if there is no repression both sadism and masochism become fully pleasurable acts. It is only when one opposes the other and the mobility of the secondary ego is impaired that sadism and masochism show signs of pain and compromise. Sadism becomes tinged with the unpleasant emotion of hate and masochism with the feeling of pain. Without repression there would be no such pain in masochism. A masochist does not crave for pain. Pleasure in pain is an impossibility. The masochist wants to enjoy certain passive situations and the concomitant pain is not his aim. It is an unavoidable evil to him. A perfect masochist would feel pure pleasure even in being crushed to death. That such individuals are not found is only a proof of the difficulty of avoiding repression where momentous questions like a matter of life and death are concerned. As a death wish cannot be repeatedly indulged in the channel for its discharge is never sufficiently developed to overcome repression.

## Conclusion

Ambivalence is not a fundamental trait of mental life, but pairs of opposite wishes are certainly fundamental. The components of such pairs of wishes may have alternate complete satisfaction in reciprocal acts and partial satisfaction with unpleasant emotion tones in retaliatory acts. They may not necessarily produce ambivalent states and even when they do, in a large majority of cases the ambivalence is removable, showing that it is a repression product. Opposite types of behaviour corresponding to reversal of subject-object relationship are not necessarily ambivalent behaviour; on the other hand they

are to be considered a proof of the existence of opposite types of wishes.

To sum up, my contention is that pairs of opposite wishes are to be found not only in love and social intercourse but also in our dealings with inanimate objects. There is no wish without its opposite counterpart. Where the object is inanimate and the wish act is not reversible the opposite counter-wish seldom goes beyond the stage of latency. The latent counterpart helps us to appreciate the characteristics of the object. In paraphrenics, in whom words or verbal images take the place of things. reversal of a wish situation even with an inanimate object may occur; my patient said he became a tree when he looked at one. In reversible acts, *i.e.*, where reciprocity is possible, both the opposite wishes can dawn upon consciousness. If the opportunities for satisfaction for one is greater than those of the other a conflict is set up within the psyche and repression results. One of the elements of the pair then tends to become unconscious. It is the opposite wish that provides the prime motive force for repression; all other factors are secondary. The primary conflict is between opposite wishes. Antitheses such as love and hate, pleasure and pain, etc., are traceable to it. Love and pleasure are the primary affects. Hate, disgust, shame, anger, pain are all repression products. Identification, projection, introjection, turning round and reversal of an instinct, ambivalence, conscience, moral values, sense of social propriety, etc. are best explained by the assumption of opposite wishes producing conflict at different points of the wish circuit.

# Proceedings of the Twenty-fifth Indian Science Congress

## PART III—ABSTRACTS

## CONTENTS

# SECTION OF MATHEMATICS AND PHYSICS

*President* :—C. W. B. NORMAND, M.A., D.Sc., F.N.I.

## Transmutation and structure of matter

1. Lecture on 'Recent work on transmutation of matter in Cambridge'.

LORD RUTHERFORD, Cambridge.

2. The radioactivity of samarium.

H. J. TAYLOR, Bombay.

The radioactivity of samarium has been reported on in a previous communication. The present paper gives an account of more recent experiments, conducted in collaboration with Messrs. D. Fraser, V. D. Dabholkar, N. V. Shah, and M. J. Gandhi. Using the method of direct registration of tracks in a photographic emulsion, a large number of measurements have been accumulated. About 5,000 expansion-chamber photographs have also been made, about 50 of which show tracks which are due to the particles emitted by samarium. In both types of experiment tracks are obtained which can scarcely be due to α-particles. They have previously been attributed to protons, assumed to be emitted by the samarium atom. The evidence for this proton emission is now very strong. Experiments have also been made to test a suggestion that the proton activity of samarium is provoked by cosmic radiation.

3. Isotopic weights by the doublet method.

F. W. ASTON, Cambridge.

For the most reliable comparison of masses by mass-spectra the particles concerned should be nearly equal when the lines they produce, resolved by a mass-spectrograph of sufficient power, will form a natural doublet. A typical example is the oxygen-methane doublet $^{16}O - {}^{12}C^{1}H_4$ at mass 16, the first one to be observed and measured. Owing to the discovery of heavy hydrogen it is possible to apply this method to determine the fundamental isotopic weights of hydrogen and carbon in terms of $^{16}O$ as standard. $^{1}H$ is first compared with $^{2}D$ by means of the doublet $^{2}D - {}^{1}H_2$ at mass 2, $^{2}D$ with $^{12}C$ by doublet $^{12}C^{++} - {}^{2}D_3$ at mass 6 and the results combined with the oxygen-methane doublet to give the constants required. These comparisons can be extended wherever suitable doublets can be produced, thus $^{16}O^{2}D_2$ can be compared with $^{20}Ne$ or with $^{40}A^{++}$ at mass 20, $^{12}C_3{}^{1}H_7$ with $^{86}Kr^{++}$ or with $^{129}Xe^{+++}$ at mass 43 and so on. About 20 isotopic weights have already been determined with accuracy approaching 1 part in 100,000 in this way.

## 4. On the ratio of the magnetic moments of iridium isotopes.

B. VENKATESACHAR *and* L. SIBAIYA, Bangalore.

The isotopic constitution of iridium was for the first time determined from a study of the hyperfine structure of its arc line λ3513·67 Å (Venkatesachar and Sibaiya: *Nature*, 1935, **136**, p. 437; and *Proc. Ind. Acad. Sc.*, 1935, **2**, p. 203). It was shown that iridium consists of two odd isotopes of mass numbers 191 and 193, the isotope 193 being twice as abundant as the isotope 191. This result was afterwards corroborated by Dempster's mass-spectrograph analysis. With the view of determining the ratio of the nuclear magnetic moments of the two isotopes, the hyperfine structure, arising from the nuclear spin moments of $-\frac{1}{2}\frac{h}{2\pi}$ and $+\frac{3}{2}\frac{h}{2\pi}$ of the isotopes 191 and 193 respectively, has been investigated for several iridium lines using an aluminized Fabry-Perot etalon.* From the results obtained for the hyperfine level separations of the isotopes, it is concluded that the ratio of the nuclear magnetic moments of Ir 191 and 193 is $-0{\cdot}92$.

## 5. Diamagnetism of cadmium.

S. RAMACHANDRA RAO *and* S. SRIRAMAN, Annamalainagar.

Single crystals of cadmium were prepared by the method of slow cooling and the principal magnetic susceptibilities were determined by the Gouy method. The influence of ferromagnetic impurities was duly eliminated. The mean values perpendicular and parallel to the hexagonal axis of the crystal were found to be $-0{\cdot}163$ and $-0{\cdot}223$ respectively. These results agree favourably with those of McLennan, Ruedy and Cohen.

The influence of cold-working on polycrystalline rods was to give a small decrease in susceptibility. On the other hand the principal susceptibilities measured with single crystals showed no variation on cold-working.

The influence of small quantities of foreign matter was also investigated. Lead when added in small amounts affected the principal susceptibility normal to the *c*-axis but not the value parallel to this axis. Small quantities of zinc did not affect the susceptibility values.

These results are examined in the light of the theory of paramagnetism of free electrons. The valency electrons appear to contribute a paramagnetic component perpendicular to the *c*-axis. There is evidence for this from electrical conductivity data. The results obtained with the alloys are examined in the light of these conclusions.

## 6. Secondary electron emission of nickel at the Curie point.

S. RAMACHANDRA RAO *and* P. S. VARADACHARI, Annamalainagar.

A study of the secondary electron emission from nickel has been made at different temperatures ranging from 30°C. to 385°C. at a constant applied potential. No sudden alteration in the secondary electron current was observed at the Curie point (358°C.). Our results are at variance with those of Tartakowsky and Kudrawjewa and of Hayakawa. Attention is drawn to the investigations of Rao wherein no abrupt variations were obtained in the photo-electric emission and soft X-ray excitation curves of nickel at the Curie point. It is difficult to understand how in such closely connected phenomena, anomalies exist in one class and not in the other. Support from this point of view is adduced for the conclusions of our investigations.

7. Magnetic birefringence of some aromatic hydrocarbons in the molten state.

W. J. JOHN, Calcutta.

In the present paper some of the important aromatic compounds have been studied for their magnetic birefringence in the molten state. The results are compared with those obtained by Chinchalkar and Mahajan for some of them in state of solution in suitable solvents. Their conclusions regarding the structures of these molecules and their influence on the birefringence are confirmed.

8. Diamagnetic susceptibilities and molecular structures.

K. BANERJEE *and* S. N. SEN GUPTA, Dacca.

Susceptibilities of some organic crystals have been measured with a view to determine the orientations of molecules in them. The method is fruitful only when a determination of space-group is available. The orientations of the molecules in benzamide, orthodinitrobenzene, metadinitrobenzene, phloroglucine dihydrate have been determined in that way. The estimated intensities of X-ray reflections agree well with the structures found magnetically. Three non-aromatic compounds namely, decahydro-$\beta$-naphthol, arcostenone, and guanidine carbonate have been measured. In these cases the magnetic anisotropies are extremely feeble, and so a Weiss magnet was used, and the crystals were suspended from an extremely thin quartz fibre. A more rigorous method of calculation than that used by the earlier workers was found necessary in these cases of feeble anisotropy. Orientations of the molecules in these crystals are deduced from the experimental results.

9. Electron map of anthraquinone crystal by Fourier summation method.

K. BANERJEE *and* J. BHATTACHARYA, Dacca.

X-ray diffraction from anthraquinone crystals has a unique peculiarity, that reflections from such *hko* planes for which $h+k$ is not divisible by 4 or either $h$ or $k$ is odd are either absent or extremely feeble. So the projection on the 001 plane has apparent translational distances of $a/2$ and $b/2$ in place of the axial lengths $a$ and $b$ of the original cell. Furthermore, the symmetries of the original cell will also be present in the projection of this quartered cell. For the measurements of the integrated intensities, a photographic photometrical method is developed. The spot of light in the Zeiss photometer was shortened to about ·2 mm. length, and each photographic spot was scanned along six equally spaced lines. The photometric curve was converted into intensity curve by the help of a wedge prepared by Robinson's method. The absolute integrated intensities were obtained from these relative values by comparison with the reflections from rock salt. The two-dimensional Fourier summation method of W. L. Bragg is applied to find the electron distributions and therefrom the atomic parameters are determined.

10. Oscillographic studies of the uni-polar electrical conductivity of carborundum.

J. K. BOSE *and* S. R. KHASTGIR, Dacca.

Oscillograms of alternating (50 cycles per second) voltages rectified by the carborundum crystal placed between mercury electrodes of large contact area have been taken for different voltages. Although the contact-point rectification has been avoided in these experiments, the direction of the current flow through the crystal has not been unique and definite and

only an average effect for a number of directions has been observed. To study uni-polar electrical conductivity in a definite direction in the crystal, the crystal has been clamped between two similar metal contact points, and the oscillograms obtained with the crystal mounted in this way have shown considerable rectification. It has been definitely shown that the observed effect is not due to differential contact-point rectification.

The values of the rectification ratio for different voltages have been computed from the oscillograms. The computed value of the rectification ratio has been found to diminish gradually with the increase of the applied voltage. This is consistent with the theoretical idea put forward by one of us as to the origin of uni-polar electrical conductivity in carborundum.

## 11. Effect of intense cooling of aluminium anticathode on the *K* emission line.

K. PROSAD *and* A. T. MAITRA, Patna.

The paper describes the study of the effects of liquid oxygen cooling of an aluminium anticathode of a special design, on the intensity and structure changes of its *K* emission line, using an X-ray spectrograph of Siegbahn's design and having a plane grating with 600 lines to the millimeter, as compared with the intensity and structure of the line when the anticathode is cooled by the circulation of water at the room temperature. Photographs were taken on the same plate under otherwise identical conditions of exposure and development and were microphotometered.

Preliminary measurements indicate that—

(1) the intensity of the line at the liquid oxygen temperature has increased by about 40% ;

(2) the spread of the line on the long wave side, observed at the room temperature, has considerably decreased at the liquid oxygen temperature and the line as a whole has become more symmetrical in structure.

Further work with aluminium and other metals is in progress.

## 12. X-ray diffraction pattern of some normal alcohols and their isomers.

K. PROSAD *and* B. N. GHOSH, Patna.

The X-ray diffraction patterns of a number of normal and isomeric alcohols have been studied by the photographic method using $CuK_\alpha$ radiation filtered through 0·2 mm. of nickel. The microphotograms reveal asymmetric structure of maxima which is interpreted as the superposition effect of two very close spacings. The relative intensities of the rings and the half width of the maxima have also been measured. They throw some light on association and the nature of the 'cybotactic' fragments in the liquid state.

## 13. Crystallite orientation in polycrystalline metals during plastic flow.

N. RAM LAL, Hyderabad (Dn.).

In continuation of the previous work (Gibbs and Ramlal, Phil. Mag., Vol. 18, p. 949, 1934) X-ray measurements of metals (tin and magnesium) at various stages of plastic flow under relatively large stress have been made. In confirmation of the results of Andrade and Chalmers, X-ray measurements show that, when a polycrystalline metal flows, that part

of the flow called the $\beta$-flow, which gradually diminishes with time is connected with a rotation of the axes of the crystallites.

## 14. The allotropes of sulphur—a study by the X-ray diffraction method.

S. R. DAS, K. RAY, *and* B. B. RAY, Calcutta.

A detailed investigation has been carried out into the structures of the diverse modifications of sulphur at temperatures ranging between −183°C. and 130°C. The chief experimental method involved was the powder photograph method due to Hull. The following important observations and conclusions have been made :—

1. Ordinary roll sulphur and flower of sulphur have identical crystalline structures ($S_\alpha$). The rings correspond to the lattice spacings : 5·65, 3·83, 3·45, 3·13, 2·84, 2·64, 2·40, 2·24, 2·11, 1·98 and 1·91 in Å.

2. Milk of sulphur and the gummy deposits of colloidal sulphur, which have till now been regarded to be amorphous, are not so. Their patterns show that they are identical in structure with $S_\alpha$.

3. Plastic sulphur, when freshly prepared, is really amorphous producing only one diffuse diffraction ring of the spacing 3·5 Å. It rapidly transforms into a hard insoluble solid mass of $S_\alpha$. But it reverts to soluble $S_\alpha$, if it is kept at about 90°C. for 8–12 hours or treated with $NH_4OH$. The fibre-like structure observed by J. J. Trillat and J. Forestier has been explained.

4. White sulphur obtained by the hydrolysis of $S_2Cl_2$, hitherto supposed as amorphous, has exhibited a well defined crystalline pattern, quite different from that of $S_\alpha$. The Bragg-spacings observed are : 4·50, 4·02, 3·57, 3·07, 2·71, 2·3 and 2·10 Å. Heated for about 36 hours or so at about 88°C., it transforms entirely and permanently into $S_\alpha$.

5. Growth of the crystal-size out of the fine powders of $S_\alpha$ has been evidenced by the lack of uniformity of intensity of the rings at and above 75°C. This fact, together with a tendency of $S_\alpha$ for transition into $S_\beta$ (monoclinic $S$) at higher temperatures, which causes a distortion of the original crystal lattice give rise to ' asterism ', when radial streaks appear on the photograph. It has also been suggested that the transition point of $S_\alpha \rightleftarrows S_\beta$ is probably lower than the commonly accepted temperature, 95·5°C. For, the phenomenon of asterism is exhibited below it.

6. All attempts in recording a pattern of $S_\beta$ failed owing, probably, to its instability at ordinary temperatures on the one hand and to the growth of size and distortion of the crystals at higher temperature on the other.

7. Liquid sulphur patterns have been obtained at 114°C., 119°C. and 128°C. and in each case only two diffuse rings corresponding to the spacing : 5·0Å and 3·46Å have appeared.

8. No appreciable change in the pattern has been observed at as low a temperature down as −183°C.

The insolubility of the various forms of sulphur has been suggested to be in some way due to the presence of $SO_2$ in the body of the crystallites.

# General Relativity, Gravitation, Astrophysics and Spectroscopy

## 15. Lecture on ' Subatomic energy in the stars '.

PROF. A. S. EDDINGTON, Cambridge.

## 16. A law of gravitation.

S. M. SULAIMAN, Allahabad.

S. M. Sulaiman has put forward the theory that the velocity of gravitation is finite. Applying this correction in Newtonian Mechanics he has derived the law of gravitational attraction as

$$-\frac{GM}{r^2}-\frac{3GMh^2}{D^2}\cdot\frac{1}{r^4}$$

where $M$ is the gravitating mass at the origin, $D$ is the velocity of gravitational influence and $G$ is the gravitational constant. Treating the extra term as a small disturbing force

(1) the advance of the perihelion comes to

$$\frac{6\pi\mu^2}{D^2h^2};$$

(2) the deflection of light particle from a star past the Sun lies between

$$\frac{16\mu}{3D^2R} \text{ and } \frac{6\mu}{D^2R};$$

and (3) the spectral shift of light from any part of the Sun is

$$\frac{\mu}{D^2a}(1+\sin^2\alpha)$$

where $R$ is the shortest distance from the Sun, $a$ is its radius and $\alpha$ is the angle between the line of sight and the radius. $\mu = GM$ and $D$ equals the velocity of light.

Equations of the orbit for $u=\frac{1}{r}$ in terms of $\theta$ and $\theta$ in terms of $u$ have been obtained in Weierstrass's function. The Two Bodies Problem is simple. The potential function for the Three Bodies Problem also has been obtained.

## 17. The dual character of light.

S. M. SULAIMAN, Allahabad.

If a light corpuscle be a binary system consisting of two components of equal and opposite charges rotating round each other and moving forward along their axis of symmetry, it would be an electro-magnetic phenomenon subject to Maxwell's equations. The electro-magnetic field will be both created and carried along by the system itself. In the transverse section the motion will be periodic. By using cylindrical co-ordinates, it can be shown that the system will be propagated with the characteristic velocity $\frac{c}{\sqrt{\mu k}}$ of the medium, which will be its phase velocity as well.

Such a rotating system, moving along the $Z$-axis and possessing both (1) momentum in the direction of $z$, and (2) a transverse periodic motion, would exhibit both the particle and the wave aspects simultaneously, according as the effect is observed longitudinally or transversely, thus showing the dual character of the light.

## 18. Lecture on 'Recent eclipse results'.

PROF. F. J. M. STRATTON, Cambridge.

The study of the physical nature and conditions of those outer layers of the Sun's atmosphere which are only accessible to instrumental observa-

tion at the short period of an occasional solar eclipse is essentially one for international co-operation. The programmes and the eclipse camps of different expeditions are chosen so as to avoid undue overlapping of common observations at nearby stations and so as to secure where possible the repetition of the more important observations at stations far apart from each other. In this way the best chances are offered for progress. In the period since 1918 the following problems have been successfully tackled: (1) The deflection of a ray of light with its confirmation of Einstein's generalized theory of relativity has been observed by British, American and German astronomers. There remains the question whether there is a small deflection in excess of that predicted by Einstein and if so, what is the cause of this deflection. (2) Variations have been observed in the structure of the corona in the course of the passage of the shadow over the Earth's surface (Italy and Britain). (3) More exact measurements of the total luminosity of the corona have confirmed its variation and the absence of any simple law of brightness with height above the Sun's limb (America, Germany and Russia). (4) The fact that the polarization of the continuous spectrum of the corona is the same for all wave-lengths (France) shows that the scattering particles reflecting the sunlight must be electrons or dust particles. (5) Either of these sources of scattering is consistent with the fact that the continuous spectrum of the corona shows the same intensity distribution with wave-length as integrated sunlight (Germany). The dust particles are held to be responsible for the Fraunhoferic lines found in the outer corona. In the theory of a corona composed of electrons surrounded by a cloud of dust particles there remain outstanding difficulties which still await solution by observations at some future eclipse. (6) Still another constituent of coronal light has yet to be identified as the source of the bright lines of the coronal spectrum. A number of fresh lines have been discovered (Great Britain, America, Germany) and the fact that lines differ in relative intensity at different eclipses and at different points on the Sun's limb has been established. Day-to-day variations in the strengths of the principal lines form part of the very valuable work now being carried on by Lyot of the Meudon Observatory at the Pic du Midi, France. He has also discovered new coronal lines in the infra-red. (7) Lyot has also measured the rotation of the corona and has shown that the coronal lines are so wide that the hopes of getting more exact wave-lengths by interferometer methods must be abandoned. Thus two problems of long standing have been removed from eclipse programmes. (8) The examination of the relative strengths of lines of the same multiplet in the chromospheric spectrum has shewn a wide difference from the theoretical values for a state of thermodynamical equilibrium (Britain, Holland, America). (9) The widths of the chromospheric lines have given estimates as to the amount of turbulence available to help to support the chromosphere (America and Great Britain). The abundance of the elements in the chromosphere has been shown to be substantially the same as in the reversing layer (America). More work remains to be done on the difficult question of the variation of intensity with height of the various chromospheric lines. So far no finally satisfactory results have been secured though valuable pioneer work has been done (Holland and America). (10) The transition from the absorption spectrum to the emission spectrum of the chromosphere has been studied by the slit spectroscope (Britain), the continuously moving plate camera (America) and by a cine-camera taking 24 photographs to the second (Japan). (11) Cine-cameras have also been used for obtaining the exact times of the second and third contacts with a view to geodetic applications of the results (Poland). (12) A geophysical problem has been in large part solved by the study of wireless echoes during a total eclipse. It is now certain that the normal *E* layer of the ionosphere is entirely ionized by ultra-violet light from the Sun, as also at least in large part the normal *F* layer. A great deal of work remains to be done at future eclipses on nearly all the above topics before we can get a satisfactory knowledge of

the nature, physical condition and behaviour of the upper layers of the Sun's atmosphere.

## 19. Theory of scattering of protons by protons.

A. S. EDDINGTON, Cambridge.

It is deduced from scattering experiments that at very close encounters the force between two protons becomes attractive instead of repulsive, so that there is a well of negative potential immediately surrounding a proton. The combination of relativity theory and wave mechanics developed in the author's *Relativity Theory of Protons and Electrons* is here applied to this problem. It is found that the existence of the potential well is a necessary consequence of the theory, and formulæ for its extent and intensity are obtained. The potential well is of Gaussian form, the energy at distance $r$ (additional to the Coulomb energy) being $-Ae^{-r^2/K^2}$, where

$$K = 2{\cdot}20.\ 10^{-13}\ \text{cm.}$$

$$A = 39{\cdot}2\ mc^2,$$

$m$ being the mass of an electron. The values of $A$ and $K$ agree with those obtained experimentally by Breit, Condon and Present.

In the corresponding problem of the encounter of two electrons, $A$ is smaller in the ratio 1/1847, so that the well potential is much less important in comparison with the Coulomb potential.

Since the potential well in this problem is fundamentally the same as that which occurs in the theory of the nucleus, the investigation has a special interest as furnishing a connecting link between extra-nuclear and nuclear physics.

## 20. Pressure ionization in white dwarf stars and planets.

D. S. KOTHARI, Delhi.

The paper gives a detailed account of the theory of pressure ionization or ionization in cold matter, i.e. matter in which any free electrons present constitute a degenerate gas in the sense of Fermi-Dirac statistics. A straightforward application of the *virial* theorem leads to a relation between the mean molecular weight (per free electron) and the density or pressure of the material. The main astrophysical results which follow from an application of the theory may be summarized as follows :—

(i) The theory *predicts* that the stellar material in the interior of the white dwarf star should be almost *fully ionized.*

(ii) It predicts the existence of a maximum radius for a *cold* body. The value of this maximum radius is about the same as the radius of the planet Jupiter. Thus *there cannot be a cold body (planet or white dwarf) bigger (from the point of size) than Jupiter.*

(iii) The theory shows that the two heaviest planets (Jupiter and Saturn) have cores composed of *metallic hydrogen.* The terrestrial planets have cores of much heavier metal, possibly iron.

## 21. The complex spectra of novæ.

F. J. M. STRATTON, Cambridge.

The normal course of development of the series of spectra shown by a nova in the course of its bright outburst may be simply stated. A spectrum of bright undisplaced bands with absorption lines at their violet end sharing a common line of sight velocity shows changes in the widths of the bright bands, the displacements of the absorption lines and the

type of spectrum present. At first the spectrum changes from an earlier (or hotter) to a later (or cooler type) and the absorption lines show a diminishing displacement while the bright bands narrow. Then a succession of absorption spectra, generally with a larger displacement and successively of earlier type emerge and in turn fade away: two such spectra are commonly present together and occasionally three such spectra can be identified as simultaneously present. As many as eight or nine such spectra can be traced before the fading away of the continuous spectrum of the star leave behind a spectrum of isolated bright bands. These pass from the *A* and *B* type, corresponding to the white and blue stars, to the *P* type corresponding to the planetary nebulæ and later to the *O* type corresponding to the Wolf-Rayet stars, the hottest known stars. The bright bands in the nebular and Wolf-Rayet stage are generally composite in structure and if the nova has grown to a measurable disc or developed into a set of multiple nuclei or condensations it may be found that different maxima in the bright bands come from different portions of the expanding nova. The velocities corresponding to the displaced maxima can frequently be related to the velocities shown by some of the earlier sets of displaced absorption lines.

The earliest simple set of phenomena can be best explained in terms of an expanding shell round a bright stellar source: the reasons why its speed diminishes at first are not known; and continuous ejection of matter from a central star may well provide the solution of some of the phenomena. The later more complex spectra require a much more elaborate model and so far no consistent picture has been formed for these later stages. It is not certain as yet whether the later more rapidly moving shells start inside the earlier ones or, like prominences on the Sun's limb, represent a sudden increase in velocity (generally to a small multiple of the earlier velocity) of the outer layers of the earlier outburst. Nor is it yet certain whether shells are to be replaced by jets of gas continuously driven off from the parent star. The study of the contours of absorption lines and bright bands, especially when successive spectral outbursts are simultaneously present should throw much light upon such questions. That the outward motion is due to increased radiation pressure, as suggested by Milne, is very probable, but the cause of the outburst of this radiation is unknown. Milne's view that we are observing the stages accompanying the collapse of an ordinary dwarf star to a white dwarf is consistent with a great many of the observed data. We do, however, need to find out more about the spectral changes of the star during its sudden rise to maximum brightness and a scheme for catching novæ at a much earlier stage than at present is highly desirable.

## 22. Intensity fluctuations in the continuous absorption spectra of some gaseous molecules—(HBr and HCl).

S. Datta, B. Chakraborti, *and* S. Banerji, Calcutta.

It is well known that good deal of controversy exists about the nature of binding of several gas molecules, particularly those of hydrogen halides. The discrepancy is mainly due to the fact that the long wavelength limits of continuous absorption from which the heat of dissociation is calculated, is fixed at different values by different observers.

A careful repetition of the absorption experiments was therefore felt desirable and this appears to be completely justified as the microphotometric analysis of the absorption records for varying pressures have revealed the following interesting features:—

(i) The long wavelength limit of continuous absorption slightly shifts towards longer wavelengths with an increase in pressure.

(ii) At higher pressures marked fluctuations of intensity are observed at the long wavelength beginning, somewhat analogous to those observed by Sommermeyer in the case of alkali-halides.

The curves showing the variation of percentage of absorption with wavelength have two distinct maxima. Interpreting their long wavelength limits as corresponding to transitions from the states $v'' = 0$ and 1 of the lower potential curve to practically the same point in the upper potential curve, the difference in the long wavelength limits correspond to the accepted values of the vibration quanta of HBr and HCl as obtained from the infra-red measurements.

(iii) Correlation between the spectroscopic value of the heat of dissociation and that obtained from thermal measurements appears to be satisfactory when the long wavelength limit is chosen corresponding to transitions from the state $v'' = 0$ and with the absorption tube at room temperature and at atmospheric pressure.

## 23. Vibrational perturbations in the lower $^2\Sigma$ state of aluminium oxide bands.

P. N. GHOSH *and* M. K. SEN, Calcutta.

From an analogy with the spectra of boron monoxide, BO, one would expect band systems yet undiscovered in the spectrum of AlO. While searching for those new band systems, the authors have recorded a number of new bands in the existing system, which is due to a $^2\Sigma \rightarrow {}^2\Sigma$ transition. It is found that the new bands with $v'' = 9$, 10, 11 and 12 are shifted from their expected positions thus giving evidence of perturbations in the lower electronic state. The perturbing state is, in all probability, a $^2\Pi$ level. Hence the existence of a new band system due to a transition $^2\Pi \rightarrow {}^2\Sigma$ and thus analogous to the $\alpha$ bands of BO has been predicted in the near infra-red region of the spectrum of AlO. The present communication deals with the assignment of vibrational quantum numbers to the new bands and discusses at length the perturbations existing in the lower state of the $^2\Sigma \rightarrow {}^2\Sigma$ band system.

## 24. A new ultra-violet band system of antimony oxide (SbO).

P. N. GHOSH *and* A. K. SEN GUPTA, Calcutta.

The authors have recorded a new ultra-violet band system in the spectrum of the diatomic oxide molecule, SbO. The bands are degraded to the violet and form two sub-groups. Each band head is itself double. The system has therefore been assigned to a $^2\Sigma \rightarrow {}^2\Pi$ transition. The lower state of the band system is in all probability, the ground state of the molecule and has a doublet separation of about 2,272 cm.$^{-1}$. From a comparison with the spectra of the homologous molecules NO, PO and AsO the band system is considered to be an analogue of the $\gamma$-system. The present communication deals with the preliminary analysis of the vibrational structure of these new bands.

## 25. Vibration temperature in relation to rotation temperature in band spectra.

N. R. TAWDE *and* S. A. TRIVEDI, Bombay.

The CN violet and the AlO blue-green systems have been excited in the same carbon arc as the source. Gross intensity distribution among the bands of the two systems has been made by photographing them simultaneously. Effective 'vibration temperatures' have been derived which come to be 6200° K. for CN and 3450°K. for AlO. These results compare very well with those of Ornstein and Brinkman from rotational energy distribution and point to the existence of thermal equilibrium of molecules within the upper vibrational states.

## 26. Study of the oxy-coal gas flame by band spectra.

N. R. TAWDE *and* J. M. PATEL, Bombay.

Swan system of $C_2$ bands has been photographed in the oxy-coal gas flame by producing the same under five different conditions. By keeping the coal-gas pressure constant, the oxygen pressure has been varied so as to get the coal-gas/oxygen ratios as 1·25, 2, 3, 4, 5. By applying the intensity laws, temperatures have been calculated for all the ratio conditions which bear with the ratios the same relation as that found by Loomis and Perott by other methods. Besides this, many other interesting aspects have been noted.

## 27. Rôle of argon in the production of Swan bands.

N. R. TAWDE *and* D. D. DESAI, Bombay.

Inert gases have been known to give rise to the production or isolation of certain spectra. This is specially so with argon which brings out the $C_2$ Swan system of carbon under certain conditions in the discharge tube. Argon was filled in discharge tubes at pressures of 10, 15, 20, 25 and 30 mm. and progressive intensity changes in the bands have been measured. Attempts have been made to arrive at the critical pressure of argon and the probable mechanism of the production of $C_2$ molecule.

## 28. The first spark spectrum of bromine, Br III.

K. R. RAO, Waltair.

In a former communication (*Ind. Sci. Cong.*, '37), (also *Proc. Roy. Soc.*, Vol. 161, p. 38, 1937), it was reported that extensive investigations on the spectrum of Bromine from $\lambda 500$ to $\lambda 6000$ led to the identification of many of the prominent multiplets of Br III. A careful assignment of the lines due to various stages has helped further in the discovery of the chief combinations of Br II lying in the very extreme and the near ultra-violet. The $4p\ ^3P$ term is found to be inverted. The intervals $4p\ ^3P_2-{}^3P_1$ and $^3P_1-{}^3P_0$ are 3147 and 691 cm.$^{-1}$ respectively. The first ionization potential of Bromine is found to be 21·1 volts.

## 29. The spectrum of argon IV.

A. BALANKESVARARAO, Waltair.

Extensive investigations on the highly excited spectrum of Argon gas from $\lambda 2000$ to $\lambda 6000$, under various experimental conditions enabled the identification of the lines due to A IV. The prominent terms due to the $4p$, $5d$, configurations are discovered. Some of the even terms are, 248927, 246618, 259764.

## 30. The spectrum of iodine IV.

S. G. KRISHNAMURTY, Waltair.

While classifying some of the intense lines of the spectrum of highly excited Iodine, for the elucidation of the structure of Iodine III, some intense lines in the visible region appeared to be due to the trebly-ionized atom. These lines along with many other lines of Iodine IV previously identified, entered into a scheme which revealed the prominent $6p$, $6s$, and $5d$ terms of I IV. The $6p\ ^3P$ term is found to present unusual anomalies as would be expected in the spectra of atoms of heavier nuclei.

### 31. Factors affecting the accurate determination of density by Zeiss Recording Microphotometer.

B. N. GHOSH, Patna.

The paper is concerned with investigation of various types of errors which have to be taken into account when making accurate determination of photographic density produced under varied conditions.

### 32. On the theory of absorption in ionized gas.

(MRS.) BIVA MAJUMDAR, Calcutta.

In the present paper a general mathematical theory is developed to investigate the problem of absorption coefficient in a system of ionized gas, subject to an external electromagnetic field. In the first part the theory is applied to evaluate the opacity coefficient in the interior of stars, the numerical calculations being given for Sun and Capella as well as for the well-known white dwarf, the companion of Sirius B. The second part brings out a further application of the theory to estimate the absorption coefficient of liquid metals which are perhaps akin in some sense to white dwarf stars and a satisfactory agreement with the observed values has been obtained. The results are then, as a whole, discussed in reference to the existing theories of Eddington and others on absorption coefficient in the interior of stars.

### 33. Can a particle be influenced by its own gravitational field ?

N. R. SEN, Calcutta.

According to the Newtonian theory of gravitation a particle is not influenced by its own gravitational field, and when several bodies are in the field, the motion of the centre of gravity of any one of them is not influenced by the part of the total field which is contributed by that body. This need not be so in Einstein's theory of gravitation. This question is examined for a single isolated particle. The treatment is complicated by certain integrals assuming infinite values. By a suitable limiting process it is possible to arrive at the following definite results which are rigorous and involve no approximation. A particle has *no* tendency to be influenced by its own gravitational field when observed from the rest system or from a system in uniform relative motion with respect to the particle. But when observed from a uniformly accelerated system, its gravitational field at itself will appear to be just of the strength to produce its own acceleration with respect to that system. This is a perfectly self-consistent result pointing to the inner consistency of the Principle of Equivalence with the Geodesic postulate from which the above results have been derived.

## Geophysics

### 34. Graphical computations of energy realizable under certain atmospheric conditions.

C. W. B. NORMAND, Poona.

The well-known examples of Margules involve lengthy computations. Approximate results can be obtained by simple means on an adiabatic diagram, e.g. on a temperature-entropy diagram. This method can be extended easily to examples of a much more general type than those worked out by Margules. Examples, in which condensation of water vapour takes place, can also be computed graphically and show how

great a factor the latent instability of water vapour may be in the development of kinetic energy.

## 35. Does rain play any part in the replenishment of earth's negative charge?

S. K. BANERJI, Poona.

At Bombay thunderstorms invariably move overhead in some east-west or west-east direction according as they are 'heat' thunderstorms or 'line-squall' thunderstorms. An analysis has been made of the charge brought down by rain during the passage of 23 thunderstorms over Bombay in the years 1930–32. This shows that the average positive charge per cubic centimetre of rain is 0·11 els. unit and the average negative charge per cubic centimetre of rain is 0·12 els. unit. These two amounts are very nearly equal to each other, but the mean amount of negative rain (namely 1·39 cm.) per thunderstorm is in considerable excess of the mean amount of positive rain (namely 0·97 cm.). The result is that on the average each sq. cm. of ground received 0·17 els. unit of negative charge and 0·11 els. unit of positive charge, and estimating that an area of (100 km.)$^2$ received charge at this rate, it is concluded that each thunderstorm transferred to the ground $5{\cdot}6 \times 10^3$ coulombs of negative electricity and $3{\cdot}6 \times 10^3$ coulombs of positive electricity. The question is, therefore, asked whether, if an analysis is made in this way of the records of charge at other stations in respect of thunderclouds which have definitely travelled overhead, rain would be found to transfer an excess of negative charge to the ground on the average everywhere.

## 36. Focal depths of earthquakes in India and neighbouring regions.

K. R. RAMANATHAN *and* S. M. MUKHERJEE, Bombay.

1. Methods of determining focal depths of earthquakes; methods available for use in India.
2. Depths of some earthquakes in the Hindu Kush region as determined from seismograms.
3. Depths of some earthquakes in Assam as determined from seismograms; comparison with information obtained from other sources. The conclusion is reached that the depth of the original disturbances of many of the earthquakes in the region of the Khasi and Jaintia Hills are 60 to 80 kms. These deeper shocks are sometimes accompanied by breaks at small depths.
4. Depths of some earthquakes in and off Sumatra.
5. The organization needed for the determination of focal depths and other characteristics of earthquakes.

## 37. The diurnal variation of magnetic disturbance at Bombay (Alibag).

K. R. RAMANATHAN *and* R. NARAYANASWAMI, Bombay.

The present paper contains an analysis of the irregular magnetic disturbances (apart from magnetic storms) at Bombay and their comparison with similar data obtained in higher latitudes. As an index of disturbance the departures of the ranges of $H$ in each hour from the corresponding mean ranges on the five international quiet days in the month, were used. The irregular disturbance variation is a function of the local time. The data used cover the period of 11 years, 1923–1933.

The main results of the investigation can be summarized as below :—

1. The hour of minimum disturbance occurs early in the morning usually between 4 to 5 or 5 to 6, and that of the maximum near about noon.
2. There is a secondary maximum at about 22 to 23 hrs. at night with an intervening minimum at about 12 to 20 hrs.
3. Analyzing the results according to month, the day maximum is more pronounced in the months April to August. In the winter months, there is a tendency for the variation to approach the European type (Eskadalemuir and Wilhelmshaven) in which there is one minimum in the morning (at about 9 hrs.) and a maximum in the evening (at about 22 hrs.).
4. If days of magnetic character 2 are excluded, the diurnal variations are similar, but the late evening maximum is suppressed leaving the noon maximum more pronounced.

It is generally believed that 'in the latitudes between the two auroral zones, that is, up to at least 65° magnetic latitude, *Di* has a simple daily variation, with its maximum in the evening as the auroral zone is approached the hour of maximum gets later, from about 21 hrs. at 55° to midnight at 70°. Up to this latitude the hour of the daily variation of *Di* does not vary much either with season or with the general intensity of magnetic disturbance' (Chapman). The present analysis of Bombay data shows that in low magnetic latitudes, the main variation is a maximum near noon with a minimum a little before sunrise. The evening maximum of temperate latitudes is superposed on this simple variation.

The probable causes of the variation are discussed.

## 38. Dust-storms of Agra.

B. N. Sreenivasaiah *and* N. K. Sur, Poona.

After briefly summarizing characteristics of 152 dust-storms which occurred at Agra between 1924 and 1930, the atmospheric structure associated with dust-storms over Agra, as revealed by certain special meteorograph ascents made by one of the authors (B. N. Sreenivasaiah) and by some other records obtained at Agra, is discussed with particular reference to the conditions of latent instability. The general conclusion which the study points to is that the existence of latent instability is a necessary condition for the occurrence of a dust-storm but is not sufficient by itself to start the phenomenon unless there is a trigger. Insolation and undercutting by cold winds, associated with cold fronts or otherwise, are seen to be suitable agencies to act as triggers to start dust-storms at Agra. The aid is taken of trajectories of air currents and synoptic weather charts to determine the trigger action and also to explain the existence of latent instability. Further study is in progress to test these provisional conclusions.

## 39. Foreshadowing formula for monsoon rainfall in Upper Siam.

V. Doraiswamy Iyer, Poona.

The formula for foreshadowing the rainfall of Upper Siam obtained with data up to 1926 is tested for its performance in the ten years, 1927 to 1936. Two of the factors included in the formula which showed poor performance are replaced by two other factors which showed a more consistent performance in the last ten years, and a new formula for foreshadowing is obtained with a joint correlation coefficient $R = 0{\cdot}71$.

## 40. Average intensity of rainfall on a rainy day in India.

V. Doraiswamy Iyer *and* Kasturinath Sobti, Poona.

Monthly charts of the average intensity of rainfall on a rainy day are prepared and discussed. The average intensity associated with winter disturbances is found to be moderate. The intensity increases gradually during the hot weather till a maximum value is reached in the monsoon. During the height of the monsoon the chief feature of the distribution is the contrast between the windward and leeward sides of the mountain ranges. In the retreating monsoon months the area of highest intensity lies along the coast of the Bay of Bengal.

## 41. Distribution of heavy rainfall over India.

V. Doraiswamy Iyer *and* Mohammad Zafar, Poona.

Two charts showing the distribution over India of heavy falls exceeding 3″ and 5″ in 24 hours are given and briefly discussed. A chart showing the heaviest fall that has occurred in different parts of India is given followed by twelve monthly charts showing the distribution of the heaviest fall in each month. Their chief features are briefly explained.

## 42. Influence of cloudiness on radiation received on a horizontal surface from the sun and sun-lit sky.

P. K. Raman, Poona.

The paper gives a summary of the mean monthly values of $S+H$ (radiation from the sun and the sky) for 1935 as measured on a Kipp and Zonen recording solarigraph under varying conditions of the sky. The mean duration of sunshine is also given for each month. The mean hourly and seasonal variation of intensity of radiation is discussed. After Angstrom and Kimball, the solar radiation values are expressed as a linear function of the ratio of actual to possible duration of sunshine. A few typical charts on cloudy days are reproduced. The radiation on days with skies overcast with different kinds of clouds is discussed in relation to the radiation from clear skies.

## 43. Distribution of gases in the upper atmosphere.

S. K. Mitra *and* H. Rakshit, Calcutta.

A problem of great importance in the study of the upper atmosphere is the estimation of the height at which diffusive equilibrium under the action of gravity begins to be important. Investigations by Maris and by Epstein show that equilibrium sets in rapidly in regions of low pressure. The question as to the level from which diffusive equilibrium will begin to be important can be settled by observations on the disturbing causes. This level should commence from the height at which the time taken for appreciable separation of the constituents is small compared with the period of the disturbance. From a consideration of disturbing winds which are known to exist at levels of 70 to 100 km. the lower limit of the height of diffusive equilibrium level may be taken as 100 km.

The upper limit is calculated after Epstein for two atmospheres, one consisting of $N_2$ and $O_2$ and the other of $N_2$ and O taking into consideration the disturbing effect due to heating and cooling. It is found that the mixing should extend up to heights of 500 km. and 350 km. respectively.

Calculations are also made of the pressures at and the masses of the two constituents existing above different levels in the upper atmosphere. The values of both of these are higher than those obtained by previous workers.

## Dielectric Constants, Ionization, Radio Waves and Scattering

### 44. Lecture on 'The dielectric constants of solid bodies'.

PROF. C. G. DARWIN, Cambridge.

### 45. Dielectric constant of ionized gases.

S. GANGOPADHYAYA *and* S. R. KHASTGIR, Dacca.

Measurements of the dielectric constant of ionized air and nitrogen have been made for ultra-high frequencies using condenser plates placed outside the discharge tube. It has been found that the value of the dielectric constant which is less than unity decreases approximately proportionately with the increase of the tube current only up to a certain value of the latter. Beyond this value the dielectric constant gradually attains the value of unity and subsequently becomes greater than one for larger tube currents. The results of our experiments have been explained as due to the formation of ionic sheaths round the inside surface of the discharge tube. By eliminating the ionic sheath formation by using an earthed cylindrical copper anode (with slits) surrounding the inside of an air discharge tube and an aluminium cathode in the shape of a straight rod along the axis of the copper cylinder, it has been found that the dielectric constant of ionized air is always less than one. An irregularity in the curve showing the values of the dielectric constant of ionized air for different ionization values still remains after the elimination of the sheath effect. It has been shown that this is not connected with Tonks and Langmuir's plasma electronic oscillations. The irregularity can perhaps be explained as due to the effect of conductivity acquired by the ionized medium.

When wavelength has been changed keeping the tube current constant, the dielectric constant of the ionized air has been found to decrease almost proportionately with the square of the wavelength up to a certain wavelength, thus showing agreement with the Eccles-Larmor formula up to that point. Beyond this wavelength the dielectric constant has been found to increase. These results are similar to those of experiments of Khastgir and A. Imam using a different method. It has been shown that turning point in the dielectric constant curve is not due to effect of plasma electronic resonance. Further experiments are necessary to elucidate the problem.

### 46. The ground-attenuation of ultra-short waves along the earth.

M. K. CHAKRAVARTY *and* S. R. KHASTGIR, Dacca.

Relative field-strengths have been measured at different distances along a straight line in an open ground from a portable ultra-short wave transmitter fitted with a quarter wave aerial. The transmitter has been of sufficient power to enable field-strength measurements to be carried out with accuracy up to a distance of 50 m. from the transmitter. A wavelength of 3·64 m. has been employed for the purpose. The receiver used has been a heterodyne receiver with an oscillator-detector circuit followed by L.F. power amplification. The L.F. alternating voltage developed across the telephones in the output circuit when the transmitter is on has been measured by a sensitive valve-voltmeter constructed for the purpose. Before any attenuation measurement has been made the frequency of the beat-note has been adjusted to a definite value with the help of an adjustable Galton whistle which has been compared with the continuous heterodyne whistle obtained in the loudspeaker connected

with an L.F. amplifier. All measurements have been made through telescopes situated at some distance.

Leaving aside only one observation for the 40 m. site which has been close to a tree, the attenuation measurements have been examined in the light of Norton's formula for ground attenuation of radio waves from a short antenna. Recognizing that some discrepancy at near distances would occur between theory and experiment due to the finite height of the aerial and the interference effect as suggested by Smith-Rose and McPetrie, attenuation curves have been computed according to Norton for suitable values of the electrical constants of the soil. The values of the electrical conductivity $\sigma$ and the dielectric constant $\epsilon$ of the ground which give agreement with Norton's formula are :

$$\epsilon = 7 \text{ e.s.u.}$$
$$\sigma = \cdot 91 \times 10^{-14} \text{ e.m.u.}$$

The values for wet ground have been however larger, viz. :

$$\epsilon = 10 \text{ e.s.u.}$$
$$\sigma = 1 \cdot 84 \times 10^{-14} \text{ e.m.u.}$$

It is significant that these values agreed in their orders of magnitude with the values obtained by the direct laboratory method.

## 47. Direct determination of the electrical constants of soil at ultra-high radio-frequency.

M. K. Chakravarty *and* S. R. Khastgir, Dacca.

In the present investigation the attenuation of ultra-short waves travelling along a Lecher wire system immersed in a specimen of Dacca soil from the first potential node has been determined for a certain range of ultra-high frequencies and for varying moisture-contents.

The theory of measurements consists in evaluating the electrical conductivity $\sigma$ and the dielectric constant $\epsilon$ of soil from the formulæ :

$$\epsilon = \left(\frac{\lambda_a}{\lambda_s}\right)^2 - \frac{\alpha^2\lambda_a^2}{4\pi^2}$$

$$\text{and } \sigma = \frac{\alpha w \lambda_a^2}{4\pi^2\lambda_s}.$$

After having measured $\lambda_a$ and $\lambda_s$, $\alpha$ is determined from the 'high-width' of the resonance curve.

The value of the dielectric constant of the specimen of the soil has varied from 3·95 (e.s.u.) at a moisture-content of 7·2% to a value of 29·4 (e.s.u.) at a moisture-content of 30·2%. The value of the electrical conductivity is of the order of $10^{-14}$ e.m.u. It has increased with the increase of moisture-content.

The value of the electrical conductivity has been found first to increase and subsequently to diminish with the increase of frequency. The range of frequencies has been from 73 to 89 megacycles/sec. The dielectric constant has been found to diminish with the rise of frequency.

It is to be noted that the values of $\epsilon$ and $\sigma$ of the particular specimen of Dacca soil agree in their orders of magnitude with the values estimated from the attenuation measurements.

## 48. On Pannekoek's theory of the upper atmospheric ionization.

M. N. Saha, Allahabad.

In 1926, Prof. Pannekoek of Amsterdam, proceeding from the present author's theory of thermal ionization, proved that the Upper Atmospheric Ionization (Ionosphere) can be explained as the result of photoelectric

action of sunlight on the gases of the atmosphere. In the present paper, this theory as well as its extension by S. Chapman is critically examined, and is shown to be capable of various improvements. But it is pointed out that a complete solution cannot be obtained unless the spectra of $N_2$ and $O_2$ are thoroughly investigated in the far Schumann region with a view to obtaining information about photo-ionization of these molecules and atoms. It is shown that the mathematical expression for the process of photo-ionization is widely different from that assumed by Pannekoek (based on Kramer's theory), but the solution of the problem presents mathematical difficulties which have not yet been overcome. Besides, it is pointed out that Pannekoek's considerations do not apply strictly to an atmosphere possessing a temperature gradient.

Making certain plausible assumptions, it is shown that the formation of different layers can be attributed to the following physical processes:

1. $F_2$-layer—it is probably due to the complete dissociation of $O_2$ into atomic oxygen during hours of sunlight by the rays of the sun, and subsequent ionization of the O atoms.
2. $F_1$-layer—its formation may be ascribed to the photo-ionization of $O_2$ to $O_2^+$ and $N_2$ to $N_2^+$ according to processes which involve the second ionization potential of these molecules.
3. $E$-layer—its formation may be ascribed to the photo-ionization of $N_2$ to $N_2^+$ and $O_2$ to $O_2^+$ according to a process which involves the first ionization potential of these molecules.

## 49. On the propagation of electromagnetic waves through the atmosphere.

M. N. SAHA, R. N. RAI, *and* K. B. MATHUR, Allahabad.

In this paper, the equations for propagation of electromagnetic waves in the Earth's Atmosphere are obtained from fundamental considerations, both when damping is present and when it is negligible. The equations are solved for vertical propagation in the case when the complex dielectric constant is regarded as constant. The results obtained in this case are identical with those of Appleton and Hartree, for reflection of the waves and for their polarization, but when the variation of refractive index is taken into account, considerably divergent results are obtained some of which have already been reported by one of the authors (R. N. Rai). It is pointed out that if the equations can be rigorously solved, much new result may be expected.

## 50. Ionization of $F$-region before sunrise.

K. B. MATHUR, Allahabad.

Curves have been drawn for the time of sunrise and sunset at different heights for Allahabad for the whole year and with the help of these curves, the height where the sun's rays are falling at the time of minimum ionization of the $F$-region just before sunrise is found. Similar calculations have been made for Washington and Slough and from these it has been shown that this height is greater in winter and smaller in summer for all the latitudes. For higher latitudes (e.g. Slough) the ionization always begins to rise after sunrise in the $F$-region while for lower latitudes (e.g. Washington and Allahabad) we can roughly say that the ionization begins to rise before sunrise in winter and after sunrise in summer.

## 51. On an exact test of association between the occurrence of a thunderstorm and an abnormal ionization.

S. S. BOSE *and* P. C. MAHALANOBIS, Calcutta.

In testing independence with $2 \times 2$ tables, if the frequencies are small $P\chi^2$ test, in general, gives underestimated probabilities. If the distribu-

tion is not very skew, Yates correction for continuity gives good approximation. If it is skew, it is always desirable to perform the exact test by the hypergeometric series.

The observations show that a significant association exists between the occurrence of a thunderstorm and an abnormal ionization in the upper air, that the association between magnetic disturbance and abnormal ionization or between magnetic disturbance and thunderstorm is not appreciable.

## 52. Raman effect at low temperature : solid toluene and solid ethylene dichloride.

S. C. SIRKAR *and* J. GUPTA, Calcutta.

The Raman spectra of solid toluene and solid ethylene dichloride have been studied at about $-190°C$. It has been observed that in the former case there is no new Raman line of appreciable intensity in the neighbourhood of the Rayleigh line and in the latter case there is a strong new line with $\Delta\nu$ equal to about 58 cm.$^{-1}$ and another new broad band at about 98 cm.$^{-1}$ The Raman spectrum observed in the latter case corresponds to that due to the *trans* configuration as observed by Mizushima and others at the temperature of solid carbon dioxide, but with the difference that the two new lines mentioned above were not observed by the said authors and that some of the lines are shifted considerably at the lower temperature. Since toluene molecule has no centre of symmetry, there is a greater chance of the occurrence of an asymmetric restoring force during lattice oscillation in solid toluene than in the case of centro-symmetrical molecules and as has been proved by the investigations by Menzies and Mills of the Raman spectra of ammonium chloride and ammonium bromide at low temperature, the Raman line due to lattice oscillation in solid toluene ought to have been more intense than those in the case of other centro-symmetrical molecules. Since the observed facts are contrary to these expectations, the new lines close to the Rayleigh line may not be due to lattice oscillation but may be due to intermolecular oscillation in polymerised groups as suggested previously.

## 53. Effect of high temperature on the Raman spectra of substances.

R. ANANTHAKRISHNAN, Poona.

Placzek's polarisability theory of the Raman effect indicates : (1) that the absolute intensities of *both* the Stokes and the anti-Stokes Raman lines increase exponentially with temperature, and (2) that the ratio of these two intensities tends to approach more and more towards unity at higher temperatures. While theory and experiment have been found to be in fair agreement in respect of (2), considerable discrepancies have been observed in respect of (1). Instead of the expected increase in the intensity of the Stokes lines with rise of temperature, a pronounced diminution in their intensity has been generally noticed. A discussion of these points and an account of some preliminary results obtained in the case of liquid carbon-tetrachloride are presented.

## 54. On the moving boundary method for the determination of absolute rates of migration and transport numbers of ions, and a verification of the theory of Kohlrausch and Weber.

N. C. SEN GUPTA, Calcutta.

The influence of the concentration of indicator solution on the velocity and transport numbers of the leading ion has been measured with rising

boundaries in the case of KCl, $KNO_3$ and $K_2SO_4$ in centinormal solutions using potassium iodoeosinate as the indicator electrolyte in different concentrations. It has been found that when the concentration of the indicator is greater than that demanded by the equation of Kohlrausch and Weber the transport number of the leading ion is practically constant being

$$T_{Cl}^{KCl} = 0{\cdot}503\,; \quad T_{NO_3}^{KNO_3} = 0{\cdot}485\,; \quad T_{SO_4}^{K_2SO_4} = 0{\cdot}511$$

within the range of experimental errors, i.e. about $\pm 0{\cdot}3$ p.c. When the indicator solution is initially too dilute the results are vitiated. The adjusted concentration of the indicator ion behind a boundary has been measured potentiometrically with potassium picrate as the indicator and 0·02N. KCl as the leading solution. It has been found that from a more concentrated solution a solution of KPic comes out at a concentration of 0·0120N. The transport number and absolute velocity of picrate ion at 35° have been found to be 0·301 and $35{\cdot}4 \times 10^{-5}$ cm./sec. respectively.

## 55. The electron affinity of the halogens.

B. N. SRIVASTAVA *and* A. N. TANDON, Allahabad.

The electron affinities of chlorine, bromine and iodine have been recalculated from the experimental measurements of Prof. Saha and Tandon published earlier by taking into account the contribution of the vibrational terms in the equation of dissociation equilibria. The dissociation temperature has been found by experimentally comparing the temperature inside the graphite tube with that of the outer surface as recorded by the pyrometer under the same experimental conditions. These new values have been used in the present calculations. The values of the electron affinity thus obtained are in good agreement with the values obtained by other workers, and are as follows :—

Chlorine 85·4 K. cal. ; Bromine 79·5 K. cal. ; Iodine 72·4 K. cal.

## 56. On the theory of semiconductors in magnetic field.

M. SEN GUPTA, Sibpur.

In the present paper a general mathematical formulation for the change of resistance of semiconductors in magnetic field (both weak and strong) is derived on the assumption of Lorentz force acting on the metal electron. The numerical calculations are given for both deformable (Bloch) and rigid (Nordheim) ionic model of lattice and a general conclusion is drawn of the correctness of Bloch's model. A critical discussion of the results so obtained is made particularly with reference to the validity of Harding's results, and the difficulties to arrive at a quantitative agreement with the observed fact are cited. Hall's constant is evaluated in both the cases of strong and weak magnetic field in Bloch's model.

## 57. The theory of molecular dissociation in upper atmospheres.

R. C. MUJUMDAR, Calcutta.

A preliminary theoretical attempt is made in the present paper to estimate the degree of molecular dissociation at different heights in upper atmosphere under the action of the ultra-violet light of the sun. It is found, as for example, that the oxygen molecules are completely dissociated at a height above the *E*-region of the Ionosphere, provided we assume a temperature of 300°K and a pressure corresponding to the average mass of oxygen and nitrogen molecules. In the light of the results obtained a critical discussion is given as to the mechanism of absorption of sun's ultra-violet radiation by the molecules present in the upper atmosphere.

58. Stratification of the ionosphere.

J. N. Bhar, Calcutta.

Calculations of atmospheric ionization are made after Pannekoek with certain modifications as to the details in the light of our present knowledge regarding the mechanism of ionization of the constituents and the distribution of same in the upper atmosphere.

It is found that if the sun is regarded as a black body at 6800°K two ionized layers are formed at the levels at which the partial pressures of atomic oxygen and molecular nitrogen are $10^{-4}$ and $10^{-3}$ dynes/cm.$^2$ respectively. The maximum ionic densities are found to be $8\times10^6$ and $2\times10^5$ electrons per cm.$^3$ nearly.

If the results of Mitra and Rakshit on the distribution of pressure with height in the upper atmosphere are used it is found that the regions of maximum ionization referred to above occur at the levels of 350 and 270 kms. nearly. These layers, though their heights are a little greater than those usually accepted, may be reasonably identified with the $F_2$ and $F_1$ regions of the ionosphere.

It is also shown that in the present state of our knowledge it is not possible to account for the existence of ionized layers much below 200 kms. on the assumption of the sun radiating like a black body at 6800°K.

## General and Applied Physics

59. Lecture on 'The method of systematic relaxation of constraints, a general method of attack on the equations of mathematical physics'.

Prof. R. V. Southwell, Oxford.

60. Studies on the spreading of certain substances on a clean surface of water.

L. A. Ramdas *and* P. S. Vaidyanathan, Nagpur.

The paper describes a series of experiments on the spreading of mono-molecular films on a clean surface of water. It is shown that the rate of spreading from the edges of a piece of camphor floating on water, depends only on the perimeter of the edge where it is in contact with water. The area of the water surface and the depth of the layer of water below have no influence on the rate of surface solution from the parent material. The rates of surface solution, and of solution in the ordinary way by diffusion from the material kept inside water, have been studied quantitatively. The former is very much more rapid than the latter. It is shown that, during the process of spreading on water, the adjacent layers of water are also dragged along, and that the film dips into the water below at the periphery of the spread area. These movements agitate the liquid column below. On illuminating the column suitably the convection can be seen from the movements of suspended particles. The fact that the spreading of a mono-molecular film on water is accompanied by vigorous convection in the water column below has been over-looked in previous work on the subject.

61. Study of instability in layers of fluids when the lower surface is heated.

S. L. Malurkar, Agra.

Rayleigh and Jeffreys have discussed the theory to determine the maximum temperature difference that could be maintained between two

layers of fluid sheets before instability started. Brunt and Low applied Rayleigh's criterion to explain the high lapse-rates near the ground. The measurements by the author and Ramdas showed, however, that very much larger lapse-rates could exist very near the ground on sunny afternoons than given by the above theory. A theory was advanced to account for the distribution of temperature near the ground taking account of radiation from successive layers. Without considering whether the temperature difference that existed between two given heights was at all possible, the actual value obtained from experiment was used as a boundary condition to derive the distribution of temperature with height. But the complete problem could be divided up into two distinct parts which can be dealt separately :—

1. Nature of temperature—height curve for a given temperature difference.
2. Maximum temperature difference that is possible in a given height interval for a given temperature distribution.

Rayleigh and Jeffreys assumed that the temperature height curve was linear. The equations used by them under steady conditions is only capable of dealing with the above linear lapse-rate. In actual practice the temperature height curve near the ground is concave upwards and resembles a hyperbolic sine curve. The problem is therefore to be dealt with from first principles so that in steady conditions the equations give nearly the observed curve. The fundamental equation of the paper is

$$(d^2/d\xi^2-a^2)^2 \operatorname{sech} \gamma\xi(d^2/d\xi^2-b^2)\chi = -\lambda a^2\pi\gamma \operatorname{cosech} \pi\gamma\chi.$$

The equation had to be solved by a new method in order to give interpretable results. The method is briefly explained. Both the problems of Rayleigh and Jeffreys are considered and results obtained suitable for computation. With Rayleigh's boundary condition the first approximation is

$$\beta g\rho c_p h^4/k\nu\theta_0\pi^4 = \frac{(1+a^2)^3}{a^2}\left\{1+(5+a^2)\gamma^2/4(1+a^2)\right\},$$

where $\rho$ is the density, $c_p$ the specific heat at constant pressure, $\beta$ is the mean lapse-rate in a given height interval $h$, $\theta_0$ the initial temperature, $k$, $\nu$ the coefficients of conductivity and viscosity of air, $\gamma$ a constant which is a measure of the concavity of the hyperbolic sine curve, and $a$ is a constant. In Rayleigh's original problem the right side of the equation would merely be $(1+a^2)^3/a^2$ with $a^2 = \frac{1}{2}$ which is equal to $\frac{27}{4}$ under the conditions of the problem. Near the surface of the ground $\gamma$ is about 1 or 2 and we need higher approximations to get at the correct value. This can be done easily with the expressions given in the paper.

It is deduced that the maximum difference of temperature that can be maintained between two given heights is dependent on the distribution of temperature with height. Under the various usual boundary conditions the temperature difference that can be maintained when the distribution curve is concave upwards is greater than if it is linear.

## 62. Some plane stress problems of non-isotropic materials.

BIBHUTIBHUSAN SEN, Calcutta.

In this paper an attempt has been made to solve two problems connected with homogeneous æolotropic material having three orthogonal planes of symmetry. The first problem considered is that of a thin circular disk rotating about a normal axis passing through its centre, and the second problem deals with the bending of a uniformly loaded beam of narrow rectangular cross section, the material in each case possessing æolotropy of the type stated above.

## 63. On the theory of liquids.

A. GANGULI, Chandernagore.

Energetics of the liquid state have been critically discussed and introducing interaction forces statistical methods have been applied for the study of structure and properties of liquids. It is suggested that liquid molecules under high internal pressure do not obey the classical statistics and incipient degeneracy sets in. By the application of van der Waal's theory of imperfect gases simple expressions for the viscosity and diffusion of liquids have been derived.

## 64. Variation in fibre strength and fibre weight per inch with the group length of fibres in Indian cottons.

C. NANJUNDAYYA *and* N. AHMAD, Bombay.

The breaking load of single cotton hairs of different lengths has been determined with a Balls Magazine Hair Tester, after making some necessary modifications. The following conclusions are drawn from the results :—

(1) The mean breaking load decreases with increase in group-length.

(2) The frequency distribution for each group-length is asymmetrical and skew.

(3) The correlation coefficient between group-length and mean breaking load of the group is just significant and a hyperbolic equation fits the length mean breaking load curve.

(4) General relations are deduced from which the mean breaking load corresponding to a group-length can be deduced either from the mean length or the mean breaking load of a cotton.

The weight per unit length of each group-length was also determined. It is found that (1) the weight per unit length decreases with the increase in group-length, (2) the conclusions of the previous workers regarding the variation of fibre weight per inch of different cottons when classified into botanical species are confirmed by the present experiments.

It is further found that the intrinsic strength shows a mild tendency to decrease with the increase in length. The correlation coefficient between mean fibre strength and mean fibre weight per unit length, obtained by pooling together all values irrespective of cotton, is high and indicates that 50–70% of the variation in fibre strength is accounted for by the fibre weight per unit length, while the remainder may be due to the occurrence of bruises, cracks, pits, etc. on the fibre surface.

## 65. The effect of twist on the strength and length of cotton fibre.

HARIRAO NAVKAL *and* NAZIR AHMAD, Bombay.

The fibre strength and the percentage contraction of five cottons have been measured with the fibre in the natural state and after inserting 25, 50 and 100 turns respectively in either direction. The following conclusions are drawn :—

(1) In general, the fibre strength first increases, reaches a maximum and then falls as the twist is gradually increased. The maximum is attained at lower twists by the shorter varieties.

(2) The left-handed twist causes a slightly higher increase in strength than the right-handed twist.

(3) The fibres contract on being twisted, the percentage contraction increases rapidly with twist and is greater for the shorter than for the longer cottons.

(4) The variability of strength and length and the skewness of the strength frequency curves are all significantly higher at 100 turns per

inch than at zero twist, the direction making no difference to the magnitude of these effects.

(5) On the whole, the amount of twist usually employed in the spinning process improves the fibre properties but this improvement is very small and can account for only a minute fraction of the increase in yarn strength resulting from the insertion of twist.

(6) The adverse effects of twist on the properties of fibre are somewhat more marked for the shorter than for the longer cottons.

(7) The molecular chain theory of structure of the fibre is capable of explaining, in a qualitative way the principal effects of twist noticed in the course of this work.

## 66. A device for determining the proportion of fibres of different length in a sample of cotton.

N. Ahmad *and* C. Nanjundayya, Bombay.

The Cotton Stapling Apparatus, designed at the Technological Laboratory (Bombay) some time ago, gives the mean length and weight per unit length of a cotton. It, however, suffers from the limitation that it does not give the frequency distribution of length, a knowledge of which is often useful not only to the research worker but also to the trade and industry. With a view to remedying this deficiency, a new attachment to the Stapling Apparatus has now been designed. The description and mode of operation of this device are given in this paper. Further, the results of experiments, conducted with a view to determining the degree of agreement with the other instruments in vogue, are also given. It i shown that this device is capable of yielding consistent results which agree well with those given by other methods.

## 67. The clinging power of cotton in relation to its other physical properties.

K. R. Sen *and* N. Ahmad, Bombay.

The clinging power for seventeen different cottons was determined at two different inclinations of the slipping fibre with an apparatus specially designed for this purpose which eliminated most of the sources of error occurring in the work of the previous authors. The effects on clinging power of exerting different pressures and of mercerization without tension were also studied. The following are the main conclusions drawn from the results :—

(1) The effect of convolutions on clinging power is greatly disturbed by the irregularities in the distribution of the former ; so much so that a *negative trend* in the relation between the two characters may exist.

(2) Coarse cottons usually possess a rough surface. For extremely coarse cottons roughness increases more rapidly than coarseness. For very fine cottons, on the other hand, the change in roughness is slow.

(3) As the surface roughness increases the amount of wax *per unit surface* increases at first, but ultimately reaches a steady value. These phenomena are fully explained by consideration of relative rates of change of the different characters involved.

(4) Clinging power tends to decrease as the relative humidity increases. Decrease of temperature also appears to reduce the clinging power, although to a considerably smaller extent.

(5) At low pressures the coefficient of friction between cotton fibres ordinarily decreases as the pressure is increased. This is ascribed to the differences in contact between the fibre surfaces. Maximum possible contact occurs for different cottons at different pressures, the critical pressure lying between 5 and 6 cms. of mercury.

(6) Mercerization without tension reduces the clinging power of fibres mainly through removal of convolutions and to some extent as a result of

smoothening out corrugations or crinkles. For inclined fibres reduction in clinging power appears to result mainly from decrease in surface crinkles.

(7) Finally, the bearing of the results on irregularity in a yarn has been discussed.

## 68. Generalized theory of the Schrage motor.

J. J. Rudra, Madras.

In a previous paper (R.G.E., 1934, Vol. 35, p. 843,) the author has given the exact and approximate theories of the Schrage motor for the cases when the axes of the commutator brushes and the secondary are coincident ($\beta = 0$) and when they are in opposition ($\beta = \pi$). In the present paper the theory of the motor for any value of $\beta$ has been worked out by a method different to that used in the previous paper. It is shown how the complete performance curves of the motor may be predetermined with the help of data obtained from no load tests on the motor. The performance curves predetermined in this manner are compared with test curves of two motors. An analysis of the motor has been made which shows that the slip voltage, in phase and quadrature components of the commutator winding, and the current in the commutator winding make definite contributions of power and the sum of these gives the total power developed by the motor.

## 69. Modifications in Leblanc phase advancer.

J. J. Rudra, Madras.

This paper suggests modifications of Leblanc phase advancer with a view to improve its range. The simplest modification is obtained by replacing the single brush set in the advancer by brushes connected together through racks and pinion arrangement. By dividing the secondary of the motor in three sections and connecting each section to a pair of advancer brushes compensation of the motor can be varied by turning the pinion.

The second modification is to provide the phase advancer with a stator containing a three-phase winding. By connecting the stator winding to a three-phase rheostat, compensation provided by the phase advancer can be varied within wide limits by changing the resistance in the stator circuit.

The third modification is to provide a three-phase winding below the commutator winding and connect the former through its slip rings to a three-phase rheostat. Compensation can be varied within wide limits by changing the resistance in the rotor circuit.

A fourth modification is a combination of the second and the third.

Tests with the second, third and fourth modifications have been carried out and the second is found to give the best results. A theory of the phase advancer having the second or third modification is under consideration.

## 70. The theory and performance of the Torda motor.

A. R. Ramanathan *and* J. J. Rudra, Madras.

Prof. Cramp has given an approximate theory of this motor (J.I.E.E., 1929, p. 756) indicating the rough limits between which the current locus of the motor lies and the complications introduced in the theory owing to the variables of the commutator winding. In this paper the authors propose a theory of the motor which, taking into account all the variables of the commutator winding, enables the complete current locus and performance curves to be predetermined. The current locus and performance curves of a 20 h.p. motor determined according to this theory are compared with test results of this motor given in Prof. Cramp's paper. The

predetermined and experimental current loci agree very well. The predetermined performance curves of the current, power factor, speed and efficiency against brake horse power agree fairly well with test results except in the case of efficiency. A probable cause of this disagreement is the increase in iron losses due to distortion of the main flux of the motor by super-imposition of the commutator winding flux on it.

### 71. Stator-fed variable speed shunt polyphase commutator motors.

A. SRINIVASAN, Madras.

Speed of the stator-fed commutator motor is varied by injecting a voltage from (*a*) a transformer with tappings, (*b*) an auxiliary winding with tappings on the stator of the motor, and (*c*) auxiliary winding on the stator of the motor and a transformer in the form of an induction regulator. This paper contains results of tests carried out to study the difference in the characteristics of motors of the three types.

### 72. Some economic considerations in the choice of electric lamps.

D. R. BHAWALKAR *and* G. D. JOGLEKAR, Calcutta.

Curves are drawn for a typical case of lighting having an average luminous output of 10,000 lumens for 1,000 hours, showing the relation between the total expenses, initial cost of the lamps, the average efficiency throughout life of the lamps, the average life of lamps and the charge per unit of electricity. The electricity charges are those usually found in India. Curves for any other particular problem can be similarly drawn and made use of in selecting lamps, whose total running cost would be the cheapest. The initial cost of lamps forms an important part of the total expenses when the rate for electricity is low, but at higher rates, it becomes insignificant. More attention should be paid to the efficiency of the lamps at higher rates for electricity.

### 73. An experimental dry cell.

G. D. JOGLEKAR *and* L. C. VERMAN, Calcutta.

No less than thirty variables enter into the manufacturing processes involved in the making of dry cells, and each one of these exerts a significant effect on the ultimate properties of the cells, such as its initial electrical characteristics, shelf life, output capacity, etc. Initial characteristics indicate *in general* the behaviour of a cell in subsequent life.

In order to facilitate the study of the effects of manufacturing variables on the initial characteristics, an apparatus has been designed by the help of which it is possible to determine the e.m.f., internal resistance, polarization, etc., as affected by a number of variables, such as the composition of depolarizer, electrolyte, dolly forming pressure, etc. By the use of this so-called experimental dry cell, a considerable saving of time is effected in determining the characteristics of various raw materials, since it avoids the necessity of having to make cells and subjecting them to regular tests.

## Mathematics and Statistics

### 74. Geometry of intersections.

F. W. LEVI, Calcutta.

The investigations of the intersection-theorems of the projective Geometry inaugurated by the classical papers of David Hilbert have

been continued by Blaschke, Thomson, Reidemeister, Ruth Moufang and others. They found a close connection between the intersection theorems and the theories of groups and of generalized fields (skew fields, alternative systems). Starting with a general investigation of all geometries satisfying the projective axioms, we follow a path similar to that in the foundation of the theory of groups by 'free groups' and 'relations'. There exists a 'free geometry' to which every geometry is homomorphic. Every axiom of intersection furnishes a 'relation'. While the topological equivalent of a relation in the theory of groups is a circuit, a relation in the geometry of intersections is represented by a tree. The paper deals with different propositions in 'free geometry' and in 'geometries with relations'.

## 75. On the theory of a non-linear partial differential equation of the elliptic-parabolic type.

M. Raziuddin Siddiqi, Hyderabad, Deccan.

The occurrence of non-linear differential equations in modern physical theories is making it imperative that such equations should be studied systematically. In several recent papers the author has developed Fourier methods for the unique solution of general non-linear equations of the parabolic and hyperbolic types.

In this paper the method is extended to the non-linear partial differential equation of the elliptic-parabolic type:

$$\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}-\frac{\partial u}{\partial t}=u^2,$$

in the domain $0\leqslant x\leqslant\pi$, $0\leqslant y\leqslant\pi$, $0\leqslant t<\infty$, satisfying the boundary conditions:

$$u(0, y\,;\, t)=u(\pi, y\,;\, t)=0\,; \quad u(x, 0\,;\, t)=u(x, \pi\,;\, t)=0,$$

$$u(x, y\,;\, 0)=f(x, y)=\sum_{m,\,n} C_{m,\,n}\sin mx \sin ny.$$

On the assumption that

$$\sum_{m,\,n} \mid C_{m,\,n} \mid (m^2+n^2)=C,$$

it is proved that one and only one regular solution exists which can be expressed in the form of a double series:

$$u(x, y\,;\, t)=\sum_{m,\,n} v_{m,\,n}(t)\sin mx \sin ny.$$

The coefficients $v_{m,\,n}(t)$ are determined with the help of a doubly infinite system of non-linear integral equations which is solved by the method of successive approximations.

## 76. On a principle of duality in circle, sphere and line geometries.

A. Narasinga Rao, Annamalainagar.

Let there be two sets of points $(x)$, $(y)$ in an $n$-dimensional space $S_n$ with a quadric $\Omega\equiv\sum_{i,j} a_{ij}x_i y_j=0\ (i, j=0,\ 1,\dots.n)$ and suppose there are certain conjugacy relations $\sum a_{ij}x_i y_j=0$ between point pairs one belonging to each set. By subjecting all the points of one set $(x)$ to an

arbitrary collineation $C$ and those of the other set $(y)$ to the associated collineation $PCP$ where $P$ is the polarity defined by $\Omega$ we get two new sets in which the conjugacy relations with respect to $\Omega$ are still preserved. Since circles, spheres and linear complexes may be represented by points in $S_3$, $S_4$, and $S_5$ with a quadric $\Omega$, we may infer from the existence of any configuration that of a dual configuration usually of a more general type.

The principle is applied to obtain generalizations of the Miquel-Clifford theorems in circle geometry, of Schläfli's Double-Six, and of certain configurations in the geometry of oriented circles and spheres in $S_n$.

## 77. Through a railway window.

A. NARASINGA RAO, Annamalainagar.

The object of this note is to obtain a mathematical description of the apparent deformation which any pattern of the landscape appears to be continuously subject to as seen by a moving observer. Since the visual separation of two objects is proportional to the angle between their directions of vision, the apparent shape of any figure may be represented by its image on the surface of a unit sphere at eye level by central projection. We have thus a streaming of the image points on the visual sphere which is completely characterized by the two statements: (i) that geodesic (great circle) arcs are deformed into geodesic arcs, and (ii) that any geodesic triangle is always in perspective with itself in any of its positions, that is, the join of corresponding vertices are concurrent at a pair of diametrically opposite points while the corresponding sides meet on a fixed geodesic. The divergence and the curl of the stream field on the spherical surface are calculated and interpreted.

## 78. Parallelism and curvature in Riemannian space.

R. N. SEN, Calcutta.

The paper deals with parallel transport of a vector, the parallelism supposed to be commutative. The Riemannian curvature at a point, which is usually expressed in terms of the Levi-Civita parallelism, has been expressed in terms of a given parallelism.

## 79. On the reciprocal linear complexes of the system of linear complexes obtained from two quaternary quadrics associated with two linear complexes.

N. CHATTERJI *and* P. N. DAS GUPTA, Calcutta.

Weitzenböck has considered the invariants and covariants of a quaternary system of a linear complex and a quadric ('Zum System eines linearen Komplexes und einer Fläche zweiter Ordnung,' Journal für Math., **137** (1910), 65–82). From the view-point of a Prepared System Turnbull has discussed the concomitants of a system of $n$ linear complexes (Proc. Lond. Math. Soc., Ser. 2, 25, Parts 4 and 5). The authors (Bull. Cal. Math. Soc., Vol. XXVII, Nos. 3 and 4) have discussed the irreducible system of invariants and covariants of two Quaternary Quadrics associated with two linear complexes. In the present paper the reciprocal lines of the linear complexes obtained in the irreducible list there given with reference to the basic quadric have been obtained and their associated geometry has been indicated.

## 80. On some properties of $G$-derivative of a function and its relation to the Logarithmic Chord.

S. MITRA *and* D. N. SEN, Patna.

Taking

$$G(x, \alpha) \equiv \frac{(x+\alpha)F(x+2\alpha)+(x-\alpha)F(x-2\alpha)-2xF(x)}{4\alpha^2},$$

its upper and lower limits of indetermination as $\alpha \to 0$ are $G^*\{F(x)\}$ and $G_*\{F(x)\}$, and if these are equal the common value is the $G$-derivative $G\{F(x)\}$.

The Logarithmic chord of $y = F(x)$ in $(a, b)$ is defined by

$$y = \phi(x) \equiv A \log x + B,$$

where $\phi(a) = F(a)$ and $\phi(b) = F(b)$.

Some properties of the derivates are first established. Relations connecting $F(x)$ with $\phi(x)$ are then obtained in terms of the nature of the values of these derivates.

## 81. On Riemann-Stieltje's integral.

D. N. SEN, Patna.

It is well known that for Stieltje's integral the property

$$\int f d\phi + \int \phi df = f(b) \cdot \phi(b) - f(a) \cdot \phi(a)$$

holds good. Pollard remarked in Q.J.M., Vol. 49 that for the Modified Stieltje's Integral the property may or may not hold good. It is proved in this paper that it is true for the Modified Stieltje's Integral as well.

## 82. On certain functions which are self-reciprocal in the Hankel-transform.

S. C. DHAR, Nagpur.

A function $\phi(x)$ is said to be self-reciprocal in the Hankel transform, if

$$\phi(x) = \int_0^\infty \sqrt{xt}\, J_2(xt)\phi(t)\, dt,$$

where $v \geqslant -\frac{1}{2}$ and is called $R_v$. If however $v = \pm\frac{1}{2}$, then it reduces to the Fourier sine or cosine transform. The functions of the latter two classes are described as $R_s$ and $R_c$ respectively.

Hardy and Titchmarsh were the first to draw attention to such self-reciprocal functions and to obtain theorems relating to them. Afterwards many workers have written on the subject. In this paper some Whittaker and other functions which are self-reciprocal have been investigated.

## 83. On the sets of transformations which convert a simple continued fraction into a half-regular one.

A. A. KRISHNASWAMI AYYANGAR, Mysore.

We owe to Lagrange a regular method of converting the negative partial numerators of a Continued Fraction into positive ones. It is proposed to study here the converse transformations which convert a

Simple Continued Fraction into what Perron calls a Half-regular Continued Fraction.

This paper is a preliminary survey, which envisages completely these transformations and points out some of their properties. There are only eight such transformations which fall naturally into three groups: $(C, C_1, C_2, C_3)$; $(P)$; and $(E_1, E_2, E_3)$, having respectively the property of *contracting*, *preserving* and *extending* the number of terms to which they are applied.

A detailed exposition of other properties and uses of these transformations will be given later on. For example, it will be shown that if $C$ be excepted, the *contracting* and *preserving* sets have the faculty of making the residues numerically less than $(\sqrt{5}-1)/2$, while the *extending* set introduces residues numerically greater than $(\sqrt{5}-1)/2$. Tietze's 'raschesten Kettenbrüchen' follow in the wake of the former transformations and include a special variety which generally simulates the Simple Continued Fraction for quadratic irrationals.

## 84. The differentiation of multiple integrals.

C. Racine, Trichinopoly.

The object of this paper is to propose a formula for the differentiation of a multiple integral over $p$-dimensional varieties immersed in an $n$-space, when these varieties depend on one parameter. This formula is a little simpler than the one proposed by Prof. G. Giraud in 'Annales de L'Ecole Normale Supérieure', 1926, XLIII, pp. 6–25. Its demonstration is much shorter.

## 85. On a special net of Quadrics.

B. Ramamurti, Annamalainagar.

The special net of quadrics obtained by taking the polar quadrics of the points of a plane with respect to a cubic surface has been studied by Schur, Töplitz, Dixon and recently by W. L. Edge (*Proc. Edin. Math. Soc.* (1936) 185-209). It is well known that such a net arises also in the same manner from $\infty^2$ cubic surfaces whose sylvester pentahedra form a linear $\infty^1$ system circumscribed to a twisted cubic $R^3$. The pentahedra are self-conjugate with respect to the net of quadrics. Conversely, given a pencil of circumscribed pentahedra of $R^3$, there is a unique net of quadrics with respect to which they are self-conjugate. This point of view leads Edge to the generalization that there is a unique net of quadrics in $[n]$ with respect to which a pencil of $(n+2)$-hedra circumscribed to a rational norm curve are self-conjugate. The object of this paper is to furnish a simple proof of the above generalization by the method of binary apolarity, and study the special net in [3] by taking up the point of view of Edge and obtain the above results. It is further shown, by making use of a result of the author published in *Mathematische Annalen*, 1935 (582–586) that the $\infty^2$ cubic surfaces correspond in a one—one manner to the points of a rational normal surface $V_2^8$ in [9]. This determination of the exact structure enables us to explain the discrepancy between the values 18 of Töplitz and the value 14 of Edge, obtained for the degree of one of the two parameters in the equation of the $\infty^2$ cubic surfaces, and to point out that the really significant one is neither of the two, but the lowest value 4, which corresponds to the 'Minimal Abbildung of $V_2^8$'.

## 86. A new approach to the calculus.

John Maclean, Bombay.

Approach to the Calculus is usually cumbered by a premature explanation of fundamental ideas connected with limits. Confusion is later

caused by the (essentially superfluous) use of differentials which appear to contradict the precision expressed in the theory of limits.

It is more natural (though probably paradoxical at first sight) to defer dealing with limits to as late a stage as possible. A full discussion of the Algebra of Increments gives the learner a chance to appreciate in an adequate degree the nature of functional variation, at the same time as he learns the essentials of the manipulative processes of the calculus. The transition from approximate equalities to the exact equations obtained from limits is then easily made, and the tremendous advantage of this is apparent.

This method has the great advantage of bringing out the intrinsic importance of a calculus of increments.

## 87. The arithmetic of Śrîdharâcârya.

A. N. Singh, Lucknow.

The present communication announces the discovery of a work called *Pâṭîgaṇita* by the famous Hindu mathematician Śrîdharâcârya who uptil now was believed to have flourished about the middle of the eighth century A.D. An abridgement of the above work, known as the *Triśatikâ*, is familiar to historians of mathematics. But the bigger work could not be found. An examination of the newly found work shows that Śrîdhara wrote before Brahmagupta (628 A.D.). Thus Śrîdhara must have lived in the sixth century and not in the eighth as has been believed uptil now.

The manuscript contains a commentary on the work, but the author of this commentary or the time of its composition cannot be determined with certainty as the manuscript is mutilated at the end. The importance of this discovery to historians of mathematics is great as a close study of the manuscript is expected to throw new light on many obscure problems relating to the history and development of mathematics in India.

## 88. On the distribution of Fisher's taxonomic coefficient.

P. C. Mahalanobis, R. C. Bose, *and* S. N. Roy, Calcutta.

In a paper published lately in the Annals of Eugenics (Vol. VII, Part II, September 1936, pp. 178–188) under the title 'The Use of Multiple Measurements in Taxonomic Problems' R. A. Fisher has obtained by the principle of maximization a certain expression based on sample readings, which he calls the taxonomic coefficient whose object is to test, on the hypothesis of a multivariate normal population, whether two samples can be reasonably supposed to have been drawn from two populations with the same means, it being known or assumed that the two populations have the same variances and co-variances. By certain general arguments and formal analogies with partial regression Fisher makes the distribution of this coefficient depend on his $z$-distribution, and then proceeds to numerical applications. The present paper makes use of hyperspace geometry and the rectangular co-ordinates developed earlier by the authors ('Normalization of Variates and the Use of Rectangular Co-ordinates in the Theory of Sampling Distributions' Sankhyā, Vol. 3, Part 1, 1937, pp. 1–40) to derive in full the sampling distribution of this coefficient. It is shown in conclusion that this is in entire agreement with the distribution supposed to be behind Fisher's numerical applications but not explicitly given in the Annals of Eugenics paper. The distribution of the coefficient, when the hypothesis tested is not true, is being worked out.

## 89. On the distribution of the means of a certain Bessel function distribution.

R. C. BOSE, Calcutta.

S. Bose has made a critical study of the following Bessel function distribution :—

$$f(x)\,dx = Ce^{-\alpha x} x^{m/2} I_m (q\sqrt{x})\,dx,$$

where

$$C = (2/q)^m \alpha^{m+1} e^{-q^2/4\alpha}, \quad \text{and} \quad q \geqq 0,\ \alpha \geqq 0,\ m > -1.$$

This distribution first arose in a specialized form in connection with the researches of the present author on the exact distribution of the $D^2$-statistics. In the present paper the distribution of the mean, of a random sample of $n$, from this population is found. It comes out as

$$C' e^{-n\alpha\bar{x}}\, \bar{x}^{(mn+n-1)/2}\, I_{mn+n-1} (nq\sqrt{\bar{x}})\, d\bar{x},$$

where

$$C' = (2/nq)^{mn+n-1} (n\alpha)^{n(m+1)} e^{-nq^2/4\alpha}.$$

Hence the distribution of the mean is of the same type as the mother population. Since the type III distribution is a special case of the distribution investigated here, Irwin's distribution of the mean of a random sample of $n$ from a type III population follows as a corollary.

## 90. On a new type of Bessel function distribution.

S. S. BOSE, Calcutta.

The properties of the following Bessel function distribution :—

$$df(y) = \text{const. } y^{n/2} . e^{\alpha y} . I_n(k\sqrt{y})\,dy$$

as a graduating frequency curve have been investigated. The moments of the equation have been calculated and its region in the $\beta_1 - \beta_2$ plane indicated. Some well-known distributions have been deduced from it as special cases and finally, the actual method of fitting a curve has been illustrated as an example.

## 91. A geometrical note on the use of rectangular co-ordinates in the theory of sampling distributions connected with a multi-variate normal population.

S. N. ROY, Calcutta.

If in a space of any number of dimensions $n$, $p$ vectors $a_i$ are given ($i = 1, 2, \ldots . p$ and $p \leqslant n$) and if the scalar products of any two of them is $a_{ij} (i = 1, 2, \ldots . p\,;\ j = 1, 2, \ldots . p)$ then it is easily seen that the minor of $a_{ij}$ in the determinant $|\,a_{ij}\,|$ is the scalar product in the space $(a_1, a_2, \ldots a_p)$ of area formed by vectors $(a_1, a_2, \ldots a_{i-1}, a_{i+1}, \ldots a_p)$ and area formed by vectors $(a_1, a_2, \ldots a_{j-1}, a_{j+1}, \ldots a_p)$, and the minor of $a_{ij}$ in $|\,a_{ij}\,|$ divided by determinant is equal to $\cos \theta_{ij} \,|\, q_i \cdot q_j$ where $\theta_{ij}$ = angle between the above hyperplanes and $q_i$ and $q_j$ are perpendiculars from the ends of $a_i$ and $a_j$ on $(a_1, a_2, \ldots a_{i-1}, a_{i+1}, \ldots a_p)$ and $(a_1, a_2, \ldots a_{j-1}, a_{j+1}, \ldots a_p)$. In a paper published in Sankhyā (Vol. 3, Part 1, 1937, pp. 1–40), under the title 'Normalization of Statistical Variates and the Use of Rectangular Co-ordinates in the Theory of Sampling Distributions', by P. C. Mahalanobis, R. C. Bose and S. N. Roy, while

many results followed from the use of hyperspace geometry, several important derivations involved the processes of algebraic induction which were not fully carried through in that paper. The present note replaces the algebraic induction of that paper by pure hyperspace geometry and thereby (i) connects the matrix of rectangular co-ordinates $\| t_{ij} \|$ for the sample with the sample dispersion matrix $\| a_{ij} \|$, (ii) shows how the fundamental quadric (9.9, p. 16 of the Sankhyā paper) is reduced to the sum of squares by the transformation (11.6, p. 20), and (iii) derives $t_{ij}$'s in terms of $l_{ij}$'s (11.6, p. 20) giving incidentally a very simple geometrical interpretation of the coefficients of $l_{ij}$'s when $t_{ij}$'s are expressed in terms of $l_{ij}$'s, and also of other algebraic expressions occurring in that paper.

## 92. The median versus the mean or any other statistic in tests of significance.

S. R. Savur, Poona.

It is shown in this paper that a general test of significance, that is a test of significance which is applicable to all cases irrespective of the frequency distributions, is better than a special significance test, that is a test which is accurate only for a particular frequency distribution or distributions. Of all the general tests that can be visualized at present the ज test is the simplest. It is also simpler than the existing special tests. Hence the suggestion is made that the ज test may be used more and more widely in place of the existing tests.

## 93. The performance test.

S. R. Savur, Poona.

The principle of the performance test is quite general. In this paper some of the applications of the test are given.

## 94. On Fisher's combinatorial methods giving moments and cumulants of the distributions of $k$-statistics.

P. V. Sukhatme, Cawnpore.

The origin of Fisher's combinatorial method of evaluating any single term in a cumulant of the distribution of $k$-statistics is discussed. It is shown that his method is a natural combination of the algebraic processes into a single operation. A parallel combinatorial method of evaluating the coefficient of the moment term in the moment of the distribution of powers and products of any $k$'s is also given.

## 95. The Ogive.

N. Sundara Rama Sastry, Madras.

From the properties of the Ogive curve of any frequency distribution of ' Pearson's types ' with high contact at both ends, an empirical formula is derived to give the equation of the curve. From this equation, the methods of obtaining the mode, median and quartils are described.

## 96. On the distribution of $\chi^2$ in samples of the Poisson series.

P. V. Sukhatme, Cawnpore.

Experimental evidence regarding the lower limit of the parameter at or above which the $\chi^2$ for samples of the Poisson series follows the ordinary Pearsonian $\chi^2$ distribution is obtained. It is found that when

the parameter has a value larger than one and the sample size is not too small, the theoretical distribution of $\chi^2$ is sufficiently closely realized for all practical purposes. It is also found that the approximation improves as the sample size increases. It is, however, emphasized that the approximation is theoretically independent of the sample size, the presence of the feature being due to the limited number of different values which the $\chi^2$ assumes when the sample values are all integers and the size and the parameter are small.

## 97. On Fisher and Behrens' test of significance for the difference in means of two normal samples.

P. V. SUKHATME, Cawnpore.

The method of tabulating the 5 per cent. values of Fisher and Behrens' $d'$ test of significance for the difference in means of two normal samples is discussed and in particular the 5 per cent. values of the quantity $d'$ for equal values of $n_1$ and $n_2$ are tabulated. It is found that although for $n_1 = n_2 = 1$ the $d'$ 5 per cent. value is larger when the variances of the sample means are equal than when they are unequal, this is not true when $n_1 = n_2 = 5$ or larger. Bartlett's expectation based on his distribution of $d'$ for small odd values of $n_1$ and $n_2$ is thus shown to be falsified.

The test is also compared with Smith's approximation and student's $t$-test in common use.

A table is provided giving values of the ordinates of student's $t$-curve for the sequence 10, 12, 15, 20, 30, 60 ... $\infty$ and the nine values less than 10.

## 98 Remark on a conjecture of Sylvester.

S. CHOWLA, Lahore.

It is proved that Sylvester's conjecture that

$$\frac{3}{\pi^2}x^2 < \sum_{1}^{x} \phi(n) < \frac{3}{\pi^2}(x+1)^2$$

where $\phi(n)$ is Euler's totient function, and $x$ is a positive integer, is false for infinitely many positive integers $x$.

# SECTION OF CHEMISTRY

*President* :—S. S. BHATNAGAR, O.B.E., D.Sc., F.INST.P., F.N.I.

## Inorganic Chemistry

### 1. An improved method of hydrogen estimation in gas analysis.

H. N. BANERJEA, Bombay.

The difficulties in correctly estimating hydrogen in the presence of hydrocarbon gases by the fractional combustion method in the Lunge Orsat gas analysis apparatus have been overcome.

Amongst the various substances examined for the purpose, dinitrosoresorcinol gave satisfactory results. Of palladium, platinum and nickel catalysts with dinitrosoresorcinol, nickel catalyst supported on Kieselguhr was found to meet the requirements.

The method of preparing the catalyst is given and the experimental details of carrying out the determination reported.

### 2. Sulphur iodide.

M. R. ASWATHNARAYANA RAO, Bangalore.

The existence of sulphur iodide has been a matter of controversy. Experimental evidence presented in this paper tends to show that sulphur iodide, though highly unstable, can exist for a time in carbon tetrachloride solutions. A dilute solution of sulphur chloride in carbon tetrachloride, when treated with dry potassium iodide at 0°C., gives a yellow solution of sulphur iodide, which, on keeping, decomposes to produce iodine and free sulphur. The iodine liberated is a qantitative measure of sulphur chloride present and iodometric titration can be employed to estimate accurately the sulphur chloride. The absorption spectra of the yellow solution have been studied and support the view that sulphur iodide has been formed by the above reaction. An increase of temperature hastens the decomposition of the iodide.

### 3. Constitution of iodic acid.

M. R. NAYAR, L. N. SRIVASTAVA, *and* A. B. SEN, Lucknow.

Iodic acid in aqueous solution has been shown to be polymerised, the polymerisation depending upon the concentration (Proc. Ind. Sci. Cong., 1937). In order to find out at what concentration a change in constitution, if any, takes place a number of physical properties were studied and their graphs compared. The following mixture law equation was employed :

$$P_{\text{soln}} = (1-x)P_{\text{solvent}}\,(x)P_{\text{solute}}.$$

where $P$ denotes the physical property like density, viscosity, surface tension, parachor, refractive index, etc. and $(x)$ and $(1-x)$ the mol fractions of the solute and solvent, respectively. $P_{\text{solute}}$ is plotted

against concentration. There is a remarkable similarity in the behaviour of various graphs, all showing definite breaks in the curves at two points corresponding to concentrations 0·1N and 0·04N.

When the degree of dissociation is determined by the conductivity method ($\alpha = \Lambda_v/\Lambda_\infty$) and plotted against log concn. a straight line graph is obtained with horizontal steps at 0·08N and 0·045N in very good agreement with the other graphs.

The dissociation curves were obtained for two temperatures 30° and 40°. While the degree of dissociation of the acid at 30° is 91% for 0·01N and 38% for 1·0N, the values at 40° for the same solutions are 92% and 37%, that is 1% higher for the dilute solution and 1% lower for the concentrated solution.

These observations are in conformity with the explanation offered previously, viz. the equilibrium :

$$1/3(HIO_3)_3 \rightleftarrows 1/2(HIO_3)_2 \rightleftarrows \underset{\overset{\displaystyle\updownarrow}{H+IO_3.}}{HIO_3}$$

## 4. Decomposition of chromates at high temperatures, Part I. The decomposition of calcium chromate.

V. T. Athavale *and* S. K. K. Jatkar, Bangalore.

The dissociation pressure curve of calcium chromate was studied and shows three stepouts in the curve at 800°, 850° and 920° corresponding with 50, 66·6 and 75 per cent. decomposition. The products corresponding to these stages and which resisted further decomposition at the temperatures of the experiments had the following compositions, viz. $8CaO.4CrO_3.2Cr_2O_3$; $3CaO.CrO_3.Cr_2O_3$; $8CaO.2CrO_3.3Cr_2O_3$. All these dissolve partly in acids leaving an insoluble residue which was identified as calcium chromate. The composition of the acid soluble portions was $8CaO.4CrO_3.Cr_2O_3$; $9CaO.4CrO_3.Cr_2O_3$ and $17CaO.6CrO_3.2Cr_2O_3$ respectively. The heats of decomposition of calcium chromate and the various intermediate compounds were calculated by the Nernst equation and were 54·3, 56·3, 63·0 and 74·0 calories for 50, 66·3, 75 and 100% decomposition respectively.

## 5. Decomposition of chromates at high temperatures, Part II. The decomposition of mixtures of calcium chromate with calcium carbonate.

V. T. Athavale *and* S. K. K. Jatkar, Bangalore.

The decomposition was studied by mixing the chromate and carbonate in the required proportion. It was noticed that so far as the equilibrium between $CrO_3$ and $Cr_2O_3$ is concerned there are only two stages in the decomposition corresponding to 33·3 and 40 per cent. decomposition. It was found that at any particular temperature the amount of the acid insoluble portion, i.e. calcium chromite from the decomposed product decreases linearly with an increase in the amount of lime added while the amount of the acid soluble portion without any change in its composition correspondingly increases. When the amount of CaO added is sufficient to convert all the Cr into the intermediate compound no acid insoluble residue is left. A supplementary fact is that if, instead of the addition of CaO, chromic oxide is added to the chromate in quantities sufficient to form the chromite, no acid soluble portion but only the insoluble chromite is obtained.

The study therefore reveals that the three intermediate compounds formed in the decomposition are (1) $8CaO.4CrO_3.Cr_2O_3$, (2) $9CaO.4CrO_3.Cr_2O_3$ which correspond to 33·3 per cent. decomposition and $17CaO.6CrO_3.2Cr_2O_3$ corresponding to 40 per cent. decomposition, the

50, 66·6 and 75 per cent. products for plain chromate being shown to be mixtures of these compounds in order and calcium chromite.

## 6. Decomposition of chromates at high temperatures, Part III. The decomposition of strontium chromate.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

The vapour pressure curve of strontium chromate (m.p. with decomposition 1160°) up to 1400° was studied. Strontium chromate like calcium chromate shows three breaks in the curve at 945°, 1125° and 1255° which correspond to 50, 66·6 and 75 per cent. decomposition respectively.

The products of decomposition dissolve partly in acetic acid, the part insoluble in acid being chromic oxide for the 50 per cent. product and strontium chromite for the two other stages. The acid soluble portion had the same composition as in the case of calcium chromates, viz. $8SrO.4CrO_3.Cr_2O_3$; $9SrO.4CrO_3.Cr_2O_3$ and $17SrO.6CrO_3.2Cr_2O_3$ respectively.

The corresponding heats of decomposition were 64·0, 78·0 and 88·2 calories for the 50, 66·6 and 75 per cent. decomposition respectively.

## 7. Decomposition of chromates at high temperatures, Part IV. The decomposition of mixtures of strontium chromate and strontium carbonate.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

A study of the decomposition of these mixtures supported the results obtained with calcium salts. The 50% decomposition product for plain strontium chromate is shown to be a mixture $8SrO.4CrO_3.Cr_2O_3$ and $Cr_2O_3$, while the 66·6 and 75% decomposition products are shown to be mixtures of the strontium chromite and $9SrO.4CrO_3.Cr_2O_3$ and $17SrO.6CrO_3.Cr_2O_3$, respectively.

A curious fact about the decomposition of these mixtures is that while pure strontium chromate begins to dissociate at 925° and pure strontium carbonate at 775° a mixture of the two begins to dissociate at 600° only. All the mixtures have got definite decomposition pressures at a particular temperature. Analysis of the gas phase shows that oxygen and carbon dioxide are in such proportions that only as much strontium carbonate is decomposed as is necessary for the formation of the intermediate compound.

## 8. Decomposition of chromates at high temperatures, Part V. The decomposition of barium chromate.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

The dissociation pressure of barium chromate has been measured. The decomposition of chromate in vacuo at 1265° showed 50 per cent. decomposition. The 50 per cent. stage had practically no vapour pressure even up to 1420°. The behaviour of the 50 per cent. stage towards acid was exactly the same as for strontium chromate. The heat of decomposition of barium chromate into the compound corresponding to the first stage was 76·0 calories.

## 9. Decomposition of chromates at high temperatures, Part VI. The decomposition of mixtures of barium chromate with barium carbonate.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

A study of the decomposition of these mixtures gave the same results as in the case of calcium and strontium salts.

The reaction between the chromate and carbonate is found to be more easy than in the case of strontium. The mixtures begin to dissociate at 740° while the dissociation temperatures for pure chromate and carbonate are 1200° and 1000° respectively. All mixtures have got definite vapour pressure at a particular temperature while the analysis of the gas phase confirmed the results given in Part IV. The intensity of the reaction between the chromate and carbonate increases in the order: calcium, strontium and barium.

## 10. New compounds of gallium, Part III.

P. Neogi *and* S. K. Nandi, Calcutta.

Gallium chlorate, bromate, iodate, basic iodate, phosphate, propionate, butyrate, maleate, fumarate, citraconate, mesaconate, silicate, molybdate and tungstate have been prepared.

## 11. New compounds of gallium, Part IV.

P. Neogi *and* N. K. Dutt, Calcutta.

Double oxalates of gallium with sodium, potassium and ammonium have been prepared. Attempts are being made to resolve them into optical isomers.

## 12. Experiments to resolve co-ordinated inorganic compounds into optical isomers, Part III. Co-ordinated compounds of zinc with active and racemic propylenediamine.

P. Neogi *and* K. L. Mandal, Calcutta.

Fifteen new compounds of tri-propylenediamine (*r*-, *d*- and *l*-) with zinc salts have been obtained and the rotations of the active varieties have been measured.

## 13. Experiments to resolve co-ordinated inorganic compounds into optical isomers, Part IV. Co-ordinated aluminium compounds.

P. Neogi *and* N. K. Dutt, Calcutta.

Wohl has succeeded in resolving the ammonium aluminium oxalate but obtained the *d*- variety only. We have, however, been able to obtain the *l*- variety also in solution. The potassium compound has also been resolved, the *d*- compound being obtained in the solid condition and the *l*- variety in solution.

## 14. Fluoberyllates and their analogy with sulphates—fluoberyllates of metal-ammine complexes.

N. N. Ray, Rajshahi.

In previous communications (*Z. anorg. u. allg. Chem.*, *201*, 289, 1931; *205*, 257, 1932; *206*, 209, 1932; *227*, 32, 103, 1936), it has been shown that the fluoberyllate ion is analogous to the sulphate ion. Several simple and double fluoberyllates, isomorphous with the corresponding simple and double sulphates, have already been studied. In the present communication complex compounds containing the fluoberyllate ion are described. The following metalammine complexes have been prepared:—

Tetrammino silver fluoberyllate (anhydrous), tetrammino silver fluoberyllate dihydrate, tetrammino cupric fluoberyllate monohydrate, diammino cupric fluoberyllate, tetrammino zinc fluoberyllate, tetrammino cadmium fluoberyllate, hexammino nickel fluoberyllate, diammino nickel

fluoberyllate, hexammino cobaltic fluoberyllate trihydrate, hexammino cobaltic chlorofluoberyllate and hexammino nickel fluoberyllate potassium iodide.

These are analogous to the corresponding metal ammine sulphates.

15. Complex compounds of biguanid with tervalent metals. Chromium-biguanid bases and their salts, Part II.

P. R. RAY *and* H. B. SAHA, Calcutta.

In continuation of our previous work (Part I, communicated to the *Journal of the Indian Chemical Society*) on chromium tribiguanid bases and its salts, we have now found that the latter undergo gradual hydrolysis giving rise to a new series of complex compounds with elimination of one molecule of biguanid. The base and a number of salts of this series have been prepared and their properties studied. The constitution of the complex, forming this new series, is represented by a bivalent hydroxo-aquo-chromium-dibiguanid ion, the hydroxo- and the aquo-group occupying cis-positions in the complex. Incidentally, a strange property of the aged solutions of chloride and bromide of this series in holding the silver halides in colloidal solution has been noticed.

16. Complex compounds of biguanid with tervalent metals. Chromium-biguanid bases and their salts, Part III.

P. R. RAY *and* N. N. GHOSH, Calcutta.

It has been shown in Part I of this series (communicated to the *Journal of the Indian Chemical Society*) that biguanid combines with chromium salts to form complexes of hexammine type—chromium tri-biguanid base and its salts. A similar series of compounds has now been obtained with a substituted biguanid like phenylbiguanid. The preparation and properties of this chromium tri-phenylbiguanid base and salts form the subject matter of the present paper.

## Physical Chemistry

17. Resonance and molecular structure. (A discourse.)

J. E. LENARD JONES, Cambridge.

18. Photosynthesis of carbohydrates in vitro. (A discourse.)

E. C. C. BALY, Liverpool.

19. A proposed general theory for the molecular structure of the polyhalides of the alkali metals, hydrogen and ammonia from the standpoint of the electronic configuration.

R. R. GOREY, Benares.

The formulæ suggested by Sidgwick and others for the structure of polyhalides postulate, in the main, a central halogen atom with 10 or 12 electrons functioning covalently. It has been shown that this assumption leads to certain deductions not warranted by facts. The covalent structure for the interhalogen compounds and the similarity in the structures of the interhalogen compounds and the polyhalides as assumed by previous workers has been shown to be inadmissible.

Definite evidence has been given from which the existence of a sextet in a halogen molecule like $I_2$ and $Br_2$ can be reasonably assumed. The possible consequences of a nuclear sextet in the interhalogen compounds and the completion of the sextet to a more stable octet, by means of co-ordinate linkages, in the molecule of a polyhalide have been worked out.

This has been found to be in fuller agreement with the chemical and physical behaviour of the interhalogen compounds as well as the polyhalides. Further, on these assumptions the postulation of the inertness of a pair of electrons as proposed by Sidgwick becomes unnecessary.

## 20. The specific resistance of metals subjected to tension and torsion.

G. Ramarao, Bangalore.

An attempt is made to study the influence of tensile and torsional forces on the specific resistance of metals. This paper deals with the effect of these forces on the specific resistance of mild steel. The tensile force is applied to a standard test piece on a Buckton testing machine. It was found that the specific resistance decreased. Torsional forces were found to have no effect on the specific resistance. The micro structure of the test piece before and after tension revealed certain interesting features.

## 21. An X-ray investigation of the crystals of *o*- and *p*-benzotoludides.

Mata Prasad *and* A. B. Khan, Bombay.

(1) The crystals of *o*-benzotoludide belong to the rhombic bipyramidal class and crystallographic measurements give the axial ratio, $a : b : c = 2{\cdot}8607 : 1 : 1{\cdot}0815$ (cf. Groth V, p. 166).

The crystals were studied by the rotation methods and the following values were found for the lengths of the axes.

$$a = 26{\cdot}116 \text{ Å}, \quad b = 9{\cdot}117 \text{ Å}, \quad c = 9{\cdot}870 \text{ Å}$$

which give $a : b : c = 2{\cdot}8645 : 1 : 1{\cdot}0825$. The planes (*okl*), (*hko*) and (*hol*) are halved when *k*, *h* and *l*, respectively are odd. The crystals belong to the space group $Q_h^{15}$ and the unit cell contains 8 molecules which are asymmetric.

(2) The crystals of *p*-benzotoludide belong to the rhombic class and the axial ratio, $a : b : c = 1{\cdot}8469 : 1 : 0{\cdot}2810$ (cf. Groth V, p. 165).

The X-ray photographs give $a = 30{\cdot}54$ Å; $b = 8{\cdot}24$ Å; $c = 9{\cdot}246$ Å and $a : b : c = 3{\cdot}707 : 1 : 1{\cdot}122$.

This shows that the *a*-axis is doubled and the *c*-axis is quadrupled. The planes (*hol*) are halved when *l* is odd and (*hko*) halved when *h* is odd. The crystals belong to the space group $Q_h^{11}$ and the unit cell contains 8 asymmetric molecules.

## 22. An X-ray investigation of the crystals of *p*-nitraniline, *p*-nitrotoluene and 1 : 8-dinitro naphthalene.

Mata Prasad *and* R. N. Merchant, Bombay.

The crystals of *p*-nitraniline belong to the monoclinic prismatic class and the axial ratio is

$$a : b : c = 2{\cdot}5198 : 1 : 1{\cdot}4215$$

(cf. Groth IV, p. 181).

The X-ray photographs give

$a = 15{\cdot}31$ Å ; $b = 6{\cdot}085$ Å ; $c = 8{\cdot}633$ Å

and $a : b : c = 2{\cdot}516 : 1 : 1{\cdot}419$.

The crystals of *p*-nitrotoluene belong to the rhombic bipyramidal class and the axial ratio is

$a : b : c = 0{\cdot}9111 : 1 : 1{\cdot}1097$ (cf. Groth).

The X-ray photographs give

$a = 6{\cdot}409$ Å ; $b = 15{\cdot}40$ Å ; $c = 14{\cdot}096$ Å

and $a : b : c = \frac{1}{2}(0{\cdot}9094) : 1 : 1{\cdot}105$.

The unit cell contains 8 molecules.

The crystals of 1 : 8 dinitro naphthalene belong to the rhombic bipyramidal class. The axial ratio is

$a : b : c = 0{\cdot}3599 : 1 : 0{\cdot}7527$ (cf. Groth V, p. 372).

The X-ray photographs give

$a = 5{\cdot}390$ Å ; $b = 14{\cdot}99$ Å : $c = 11{\cdot}35$ Å

and $a : b : c = 0{\cdot}3595 : 1 : 0{\cdot}7571$.

The until cell contains 4 molecules.

## 23. Absorption spectra and magneto-optical rotation of liquid mixtures.

P. L. Kapur *and* M. R. Verma, Lahore.

Absorption spectra and the magneto-optical rotation of binary liquid mixtures comprising both polar and non-polar constituents have been measured. The results are discussed from the point of view of dipole association and molecular compound formation.

## 24. Magnetic susceptibility and particle size.

S. S. Bhatnagar, M. R. Verma, *and* P. N. Dhir, Lahore.

The magnetic susceptibility of various grades of chemically pure powders of white tin down to about 0·5 has been measured and found to be constant. These results are in line with the previous observations reported from this laboratory for Bi, Sb, Pb, Cu, S and Te.

## 25. Diamagnetic susceptibilities of mercury in various states of combination.

S. S. Bhatnagar, M. B. Nevgi, *and* G. L. Ohri, Lahore.

In this communication the diamagnetic susceptibility constants of mercury in different states of linkage have been critically examined. Data for inorganic, organic and semi-organic mercuric compounds, mercurous inorganic compounds, double salts of mercury and mercury salts in the dissolved state have been given. The specific and atomic susceptibilities of mercury are almost the same as obtained by Vogt, Bates and Tai. The susceptibility constants for mercury in the divalent state from inorganic compounds lie between $-46{\cdot}0 \times 10^{-6}$ and $-48{\cdot}0 \times 10^{-6}$ while those from the true organic compounds come out to be $-35{\cdot}0 \times 10^{-6}$ to $-37{\cdot}0 \times 10^{-6}$. The susceptibility constants from semi-organic compounds lie in between the two values mentioned above. The difference has been explained on the assumption of the difference in the degree of dissociation causing the deformation in the ions to a different extent. The mercurous

compounds are all diamagnetic. The constants for mercurous mercury are $-(51{\cdot}6)_2 \times 10^{-6}$ and $-(53{\cdot}6)_2 \times 10^{-6}$. The molecular diamagnetic susceptibilities of mercury double salts are slightly higher than the sum of the constitutive simple salts. This increment has been explained on the co-ordinate linkage. The specific susceptibilities of mercury salts in pyridine are rather low when compared with those in the solid state. This abnormal behaviour has been explained on the complex formation in organic solvents such as pyridine.

## 26. Diamagnetism of colloidal electrolytes.

M. B. NEVGI, Lahore.

The object of the present investigation is to study the constitution of the colloidal electrolytes by investigating the diamagnetic susceptibilities of some potassium and sodium salts of the fatty acids in the solid state. From the results obtained it appears that there is a substantial agreement between the theoretical and experimental diamagnetic molecular susceptibilities of sodium and potassium salts of the lower fatty acids as the general expression :

$$\chi_M = \chi_{\text{ion}}{}^{+} + \chi_{\text{ion}}{}^{-}$$

holds good, these compounds being strong electrolytes. However, no such agreement is seen in the case of the salts of the higher fatty acids. The experimental diamagnetic susceptibilities of these salts are decidedly lower than the theoretical values. This anomalous behaviour has been attributed to the micelle formation, low electrical conductivity and degree of dissociation which may be deforming the ionic radii owing to the limitation of the effective spread of the electron density distribution on which diamagnetism mainly depends.

## 27. Diamagnetic susceptibilities of some inorganic liquid compounds.

M. B. NEVGI, Lahore.

The specific and molecular susceptibilities of some inorganic liquid compounds such as $SCl_2$, $S_2Cl_2$, $SOCl_2$, $SO_2Cl_2$, $SO_3HCl$, $SiCl_4$, $SiBr_4$, ICl and $POCl_3$ have been determined during this investigation. While finding out the diamagnetic susceptibility constants from them only Pascal's atomic diamagnetic values have been used as the compounds exist mostly in the covalent state. The various susceptibility constants are as follows :—

| | |
|---|---|
| Sulphur in the divalent state | $-9{\cdot}0 \times 10^{-6}$ |
| Sulphur in the tetravalent state | $-6{\cdot}8 \times 10^{-6}$ |
| | $-5{\cdot}5 \times 10^{-6}$ |
| Silicon in the tetravalent state | $-4{\cdot}2 \times 10^{-6}$ |
| | $-3{\cdot}6 \times 10^{-6}$ |
| Iodine in the positive monovalent state | $-3{\cdot}7 \times 10^{-6}$ |
| Phosphorus in the pentavalent state | $-3{\cdot}3 \times 10^{-6}$ |

There is a substantial agreement between the theoretical and experimental diamagnetic susceptibility constants of the above elements in various states.

## 28. Diamagnetic susceptibilities of formic and acetic acid solutions.

V. NEHRA *and* M. QURESHI, Hyderabad (Deccan).

The diamagnetic susceptibilities of solutions of formic and acetic acid over a wide range of concentrations between 0% and 100% have been determined by Gouy's method. The accuracy of the measurements is about 0·5%. The results indicate definite departures from a linear change of susceptibility with concentration. The formic acid curve shows a minimum at about 77% and a maximum at about 30%. The former has been attributed to the existence of a complex formed by the close association of highly polar molecules of formic acid and water. The latter cannot be attributed solely to the depolymerisation of water molecules. The cause of it must be looked for in some kind of change taking place in the structure of the formate ion.

The acetic acid curve follows a linear course except for a single minimum at 77%, corresponding to the composition, $CH_3COOH, H_2O$. The existence of a monohydrate of acetic acid is also indicated by other physico-chemical data, such as those of viscosity, density and Raman effect.

## 29. The *p*H of aqueous solutions containing boric acid and hydroxylic substances.

S. M. MEHTA *and* (MISS) K. V. KANTAK, Bombay.

The hydrogen ion concentration of aqueous solutions containing boric acid and a hydroxylic substance such as mannitol, erythritol, glucose, galactose, maltose, mannose, tartaric acid, citric acid and others was measured at 30°C. using the quinhydrone method in conjunction with the electrometer triode circuit described by Mehta (*J. Univ. Bom.*, 1936, 5(2), 77). The concentrations varied between 0·2M and 0·005M while the ratio boric acid : hydroxylic substance was between 3 : 1 and 1 : 3. The *p*H has been plotted against concentration and against the ratio boric acid : hydroxylic substance. The results show that the *p*H-ratio curves are straight lines in the case of lævulose, galactose, malic acid, tartaric acid and oxalic acid while in the case of erythritol, glucose, mannose, mannitol and *p*-hydroxybenzoic acid maxima are obtained in the curves which indicate the possibility of complex formation.

## 30. Aqueous solutions of sodium aluminates.

(MISS) O. JOSEPH *and* MATA PRASAD, Bombay.

Solutions of aluminium hydroxide in sodium hydroxide containing different ratios of $Na_2O : Al_2O_3$ have been prepared by different methods and their electrical conductivities and hydrogen ion concentrations have been measured. The glass electrode has been employed for the measurement of the H-ion concentration. The results show a discontinuous variation in both the equivalent conductivity and H-ion concentration values with the change in the $Na_2O : Al_2O_3$ ratio.

On keeping solutions of aluminium hydroxide in solution of sodium hydroxide of various concentrations in vacuum, crystals have been observed to separate out. These have been analysed and formulæ have been assigned to them.

## 31. On an equation for the viscosity of binary systems.

P. B. GANGULY *and* S. K. CHAKRABERTTY, Patna.

In a previous paper (*Zeit. anorg. Chem.*, *231*, 304, 1937) the viscosity of ideal binary systems has been sought to be expressed by the formula

$\log \eta/\eta_1 = Ax_2 + C$, where $x_2$ represents the molar fraction of one of the components. This equation has been further examined for twelve more systems and has been found to be applicable. It has been found that the above expression can be deduced from Andrade's equation

$$\eta v^{\frac{1}{2}} = Ae^{\frac{cv}{T}}$$

on the basis of certain assumptions. The assumptions have been discussed and an attempt has been made to apply the above equation to the case of non-ideal systems.

## 32. Vapour phase esterification equilibria.

T. SUBRAMANYA *and* S. K. K. JATKAR, Bangalore.

We have studied the equilibria in the catalytic esterification of acetic acid by isoamyl alcohol. A limit is reached at about 50 per cent. conversion of equimolecular mixture although the actual limit is considerably higher, owing apparently to the simultaneous establishment of other equilibria as in the case of ethyl alcohol and acetic acid.

## 33. Primary and secondary dissociation constants of cis- and trans-norpinic, pinic, and trans-caronic acids.

C. T. ABICHANDANI *and* S. K. K. JATKAR, Bangalore.

Electrometric titration of cis- and trans-norpinic acids, pinic acid, and trans-caronic acid has been carried out for the determination of the titration curve and calculation of the first and second dissociation constants with a view to throw light on the configuration of the acids. A study of the comparison of the first and second dissociation constants of the homologous straight chain dicarboxylic acids with the corresponding cyclobutane dicarboxylic acids has been made which enables the decision in regard to the cis-trans configuration of the pinic and norpinic acids. Thus the trans structure of pinic acid has been confirmed. The following are the values of dissociation constants $K_1$ and $K_2$ respectively :—

(1) Cis-norpinic acid, $K_1 = 1{\cdot}34 \times 10^{-4}$, $K_2 = 3{\cdot}75 \times 10^{-6}$,
(2) Trans-norpinic acid, $K_1 = 3{\cdot}8 \times 10^{-4}$, $K_2 = 6{\cdot}7 \times 10^{-6}$,
(3) Pinic acid, $K_1 = 1{\cdot}37 \times 10^{-4}$, $K_2 = 6{\cdot}05 \times 10^{-6}$,
and (4) Trans-caronic acid, $K_1 = 2{\cdot}48 \times 10^{-4}$, $K_2 = 7{\cdot}9 \times 10^{-6}$.

## 34. The kinetics of the heterogeneous reaction between chromic sulphate and manganese dioxide.

MATA PRASAD *and* M. A. NAQVI, Bombay.

Manganese dioxide has been prepared by various methods and its rate of reaction with chromic sulphate solutions studied at different temperatures using (1) particles of different size, (2) different amounts of manganese dioxide, and (3) different concentrations of chromium sulphate solution. It has been observed that the reaction commences as soon as chromic sulphate solution is added to manganese dioxide and is very rapid in the beginning but slows down considerably after some time.

## 35. The hydrolysis of sulphur chloride at the interface between carbon tetrachloride and aqueous sodium hydroxide.

B. S. RAO, Bangalore.

Further work on hydrolysis of sulphur chloride is reported (cf. B. S. Rao, *Proc. Ind. Sci. Congress*, 1931). The hydrolysis of sulphur chloride at the interface between carbon tetrachloride and aqueous sodium hydro-

xide yields free sulphur in the carbon tetrachloride solution and sulphide, sulphite, and thiosulphate in the aqueous phase. Disulphur oxide ($S_2O$) seems to be the primary product of the reaction. This rapidly decomposes at the interface giving sulphur in the carbon tetrachloride solution and sulphur monoxide in the aqueous phase. The sulphur monoxide readily forms thiosulphate with the alkali. Part of the disulphur oxide reacts with alkali to give the sulphide and the sulphite of sodium. It is shown that the sulphur in the carbon tetrachloride solution and the thiosulphate in the aqueous solution are not produced by any secondary reaction between sulphide and sulphite.

## 36. A possible suppression of hydrolysis of mercuric chloride in aqueous solution by benzoic acid.

D. N. SOLANKI, Benares.

The results for the specific conductivity of benzoic acid at N/100, N/150 and N/200 in the presence of $HgCl_2$ in the range 0·25N to 0·01878N at 25°C. show that the above quantity is diminished in the presence of the latter. This diminution at a given concentration of benzoic acid is sensible only at larger dilutions of $HgCl_2$.

The comparison of the reduced (i.e., corrected for the hydrolysis of $HgCl_2$, the degree of hydrolysis for the dilutions used being extrapolated from Ley's data (*Z. physikal. Chem.*, *30*, 249, 1899), specific conductivity of benzoic acid with the actual value in the mixture obtained by difference shows that the common ion effect, arising out of the hydrolysis of $HgCl_2$ is one factor leading to a diminution in specific conductivity of benzoic acid.

Results for the specific conductivity, corrected for hydrolysis, depart from those obtained by difference or by the additive law, in the case of strong solutions of $HgCl_2$. This discrepancy might arise possibly from the fact that extrapolation made on the assumption, viz., negligibility of hydrolysis at very high concentration, is not rigorously accurate, i.e. it indicates more hydrolysis than what obtains under the conditions. The assumption that a weak acid like benzoic acid would not affect the conductivity due to a strong electrolyte like NaCl, KCl, etc., however, does not seem to be strictly true in the case of $HgCl_2$, which agrees with the fact that $HgCl_2$ stands apart from the strong electrolytes in having some of the properties of a weak electrolyte. It is likely that this hydrolysis is sensibly suppressed by the presence of benzoic acid. Simms (*J. Phys. Chem.*, *33*, 745–754, 1929) has shown some evidence for the possible inactivation of a weak electrolyte in the presence of another. The divergence from the specific conductivity of benzoic acid deduced from the additive law, of its conductivity, when corrected for hydrolysis of $HgCl_2$ is greater the greater the concentration of benzoic acid, which suggests that since the extrapolation is a common factor, the above hydrolysis is affected (suppressed) by benzoic acid.

## 37. Circular dichroism observed in sols of tungstic acid, vanadic acid and chromic tungstate.

J. C. GHOSH, T. BANERJEE, *and* S. K. MUKHERJEE, Dacca.

Weigert discovered the important fact that light might act as an orienting force upon colloidal systems in the solid gel form. A photochloride exposed to strong plane polarised light shows photodichroism. Zocher has shown that similar experiments with circularly polarised light on a thin layer of photochloride produced circularly dichroic spots. We have prepared sols of tungstic acid, molybdic acid, vanadic acid, uranic acid, chromic hydroxide and chromic tungstate. The sols have been matured by exposure to *d*- or *l*-circularly polarised light for 8 to 12 hours. No circular dichroism could be found except in the case of tungstic acid,

chromic tungstate and vanadic acid sols. In the case of these sols, however, measurement of the extinction coefficient of *d*- and *l*-circularly polarised light at wavelength $366\mu\mu$, gave values of anisotropy factor which are much greater than the limits of experimental error.

The results are given in Table I. It will be seen that the values of anisotropy factor are of the order of 0·028, which are comparable with the values obtained by Kuhn for solutions of optically active substances. The results clearly indicate that in these cases, during the process of the formation of the particles of the sol, circularly polarised light exercises an orienting effect resulting in the formation of an aggregate which exhibits optical anisotropy.

TABLE I.

| Sol used with concentration (C). | Nature of light in which the sol was matured for H hrs. immediately after mixing the reagents or dialysis. | Absorption coefficient in *l*-circularly polarised light. ($A_l$) | Absorption coefficient in *d*-circularly polarised light. ($A_d$) | Anisotropy factor. $g = \frac{A_l - A_d}{\frac{1}{2}(A_l + A_d)}$ |
|---|---|---|---|---|
| Tungstic acid .. | *l*-circularly polarised | 5·23 | 5·09 | +0·0271 |
| C = 0·0125M .. | *d*-circularly polarised. | 4·91 | 5·02 | −0·0221 |
| H = 6 hrs. | | | | |
| | Plane polarised .. | 4·83 | 4·87 | −0·0082 |
| | Unpolarised .. | 5·32 | 5·29 | +0·0056 |
| | Kept in the dark .. | 5·01 | 5·001 | +0·0001 |
| Vanadic acid .. | *l*-circularly polarised. | 5·62 | 5·46 | +0·0289 |
| C = 0·0025M | *d*-circularly polarised. | 5·53 | 5·56 | −0·0054 |
| H = 10 hrs. | | | | |
| | Plane polarised .. | 5·54 | 5·52 | +0·0036 |
| | Unpolarised .. | 5·70 | 5·67 | +0·0053 |
| | Kept in the dark .. | 5·76 | 5·71 | +0·0087 |
| Chromic Tungstate. | *d*-circularly polarised. | 6·24 | 6·42 | −0·0284 |
| C = 0·02M | Plane polarised .. | 6·45 | 6·40 | +0·0077 |
| H = 10 hrs. | | | | |
| | Unpolarised .. | 5·97 | 5·96 | +0·0017 |
| | Kept in the dark .. | 5·97 | 6·01 | −0·0067 |

## 38. Photo-reduction of aqueous solution of ferric chloride in the presence of aldehydes.

MATA PRASAD *and* C. R. TALPADE, Bombay.

The reduction of ferric chloride in the presence of formaldehyde and acetaldehyde has been studied in visible light of various wavelengths. The amount of reduction has been estimated by titrating ferrous ions against a standard solution of ceric sulphate. The effects of varying (1) the concentration of ferric chloride and that of aldehydes, (2) the temperature and (3) the hydrogen ion concentration of systems undergoing photochemical change, have also been examined. The order of the reduction is unimolecular under all circumstances.

## 39. Electro-deposition of chromium from potassium dichromate baths. Part IV. In presence of fluoride.

S. RAO *and* S. HUSAIN, Hyderabad (Deccan).

Electrolysis of potassium dichromate baths containing 0·1M to 0·2M potassium-hydrogen fluoride with a low current density at 40°C. gives

dull white deposits, whereas those obtained from a potassium dichromate bath are bright. The current efficiency was 4 to 7%.

The presence of hydrogen ions is absolutely essential; a definite concentration of these must be maintained at the cathode. Too low or too high a current density is not favourable for chromium deposition.

## 40. The influence of non-electrolytes on cathode efficiency of copper deposition.

S. S. JOSHI, D. N. SOLANKI, *and* T. V. SUBHA RAO, Benares.

The effect of organic non-electrolytes—ethyl alcohol, methyl alcohol, acetone and glycerine—on cathodic efficiency of copper was studied quantitatively by electrolysis of a solution of coppor sulphate (13% $CuSO_4$, $5H_2O$), acidified with sulphuric acid (about 4·4%), containing varying concentrations of the non-electrolyte. A steady current of 50 milli amp. was used for the electrolysis; the area of the coppor cathode used was 10 sq. cm. The concentration of the non-electrolyte was varied up to 20% by volume. The cathodic efficiency is found to increase with the concentration of the non-electrolyte till a limiting value is reached for the mass of the copper deposited, further addition seems to have almost no further effect, though in the case of acetone there is a tendency for the value to diminish after the limiting value is reached. Though it is not clear as to how the addition of alcohols and other non-electrolytes affects the conditions of the bath, the increase in the mass of the Cu deposited (and also cathode efficiency) with the concentration of the nonelectrolyte can be best explained on the assumption that 'the alcohol decreases the concentrations of the copper ions and therefore the solubility of the copper in copper sulphate solutions, in close accord with the supposition of Forester and Siedel (*Zeit. anorg. Chem.*, *14*, 106, 1897).

## 41. Effect of colloids on the electro-deposition of nickel on copper.

V. S. PURI *and* V. S. BHATIA, Lahore.

The electro-deposition of nickel from nickel sulphate bath on copper plates in the presence of prussian blue, silver, ferric oxide and arsenious sulphide sols has been studied. A dull and very rough deposit is obtained in the presence of arsenious sulphide while the presence of other sols yields a comparatively lustrous and smooth deposit. The nature and concentration of the sol seem to affect the nature and amount of deposit.

## 42. The influence of alternating electric fields on the viscosity of colloids.

S. S. JOSHI *and* G. N. KADHE, Benares.

In the present work, the transpiration times for pure liquids flowing through a continuous capillary path of about 5 feet in length and subjected to alternating electric fields, disposed equatorially to the plane containing the capillary windings, were determined in an air thermostat under identical conditions, with and without the field. The viscosity was not sensibly affected in the case of pure liquids and aqueous electrolytes at different concentrations. A small but reproducible definite diminution was established in the case of colloids (different strengths of $AS_2S_3$, $Sb_2S_3$, $MnO_2$, $Fe_2O_3$ and molybdenum blue). The effect was absent with stationary potentials for all the systems mentioned above; with A.C., it is more pronounced the greater the frequency of the applied field. The results are discussed in the light of the micellar charge, size, a postulated relaxation-time and other quantities partly from the standpoint of Debye-Hückel's theory.

### 43. Initiation of the photographic activity in the neighbourhood of gases subjected to electric discharge.

S. S. JOSHI *and* P. RAJU, Benares.

The action was investigated by exciting a given gas at a given pressure in the annular space of a glass ozoniser of the Siemen's type with the sensitive film in close vicinity from outside. It was observed that a minimum critical potential had to be applied to the gas, when alone the latent image is produced on the film. Detailed data are given for the variation of this pot potential, called the threshold potential in the case of air over a wide range of pressures, viz. 0·2 to 30 cm.Hg at two frequencies, of the electrical supply, viz. 50 and 500 cycles per second. The threshold potential was found to be sensibly a linear function of the gas pressure at a constant frequency. In numerous cases of chemical reactions produced under electrical stimulation as investigated in these laboratories, the threshold potential was found to be one of the principal determinants of the change; the present data suggest the need of extending the above concept to the occurrence of quasi-chemical reactions.

### 44. Studies in active nitrogen, part I.

S. S. JOSHI *and* A. PURUSHOTTAM, Benares.

Active nitrogen was obtained with a condensed, series-spark discharge in a Rayleigh tube actuated by an induction coil. Data are obtained in regard to the influence of heat from (*a*) liquid air temperatures to (*b*) 200°C., (*c*) 'the wall effect', (*d*) the effect of mercury vapour, and of (*e*) electrical fields. No sensible change in the intensity of the 'after glow' occurs on exposures to temperatures in the neighbourhood of (*b*). There is first a brightening followed by a quenching of the after glow at liquid air temperatures for which an explanation is suggested. Contrary to some views in the literature on the subject (*d*) and (*c*) were not found to be appreciably potent, the latter having been examined with uncontaminated materials. It is also observed that under certain conditions a marked spectral shift comes about in the 'after glow' on exposure to emissions from a heavy condensed discharge, the latter being optically screened from the seat of the after glow. This fact, indicative of a possible utilisability of active nitrogen in a coherer effect, does not appear to have been recorded hitherto in the already very extensive and rapidly growing literature on active nitrogen.

### 45. Behaviour of phosphine under electrical discharge.

S. S. JOSHI *and* R. KRISHNAN, Benares.

The behaviour of phosphine has been investigated for the spark and the silent electric discharge over a wide range of gas pressures and applied voltage. The course of the reaction and nature of the final products obtained under these conditions were found to be much more complex than what obtains in the thermal and the photochemical reaction. Free phosphine was not, in general, present after its exposure to the discharge for a reasonable time. Red-green-yellow coloured deposits and hydrogen were produced in the last stages, when the velocity of decomposition even under intense electric fields became very slow. The solid residue was found to be sensibly free of phosphorous. It is presumably a mixture of a number of hydrides of phosphorus, or perhaps of their adsorption complexes with hydrogen as a constituent. This last could be obtained by subjecting the coloured deposit to the discharge. This release of hydrogen, interestingly enough, occurred *per saltum*, corresponding to a series of synchronous discontinuities on the pressure-time and current-time curves. Essentially similar coloured products and discontinuities were obtained when free phosphorous was subjected to

the discharge in an atmosphere of hydrogen at low pressures. The occurrence of any of the above reactions was found to be conditioned by the 'threshold potential'.

## 46. The decomposition of nitrous oxide under electric discharge.

S. S. JOSHI *and* R. R. GOREY, Benares.

It has been observed during the studies on the progress of numerous chemical and quasi-chemical reactions, that a quantity called the 'threshold potential' represented the minimum value of the alternating electric field, which has to be exceeded in order to provoke chemical reactivity in the ionisation space. In experiments now reported the above decompositions were studied sensibly at the 'threshold potentials'. Under these conditions, as in zero order reactions, the amount of the change was found to be constant over a wide pressure range, viz. 11 to 50 cm.Hg, the frequency of the electrical supply being kept constant. The progress of a given decomposition at the 'threshold potential' showed at least two stages constituting the total change. During the first stage, which is comparatively short-lived, the rate of change was high; in the next stage, the above quantity got reduced very considerably. A study of the associated electrical quantities, such as the ionisation current, the energy dissipated in the reaction space during the change, etc. has shown the marked influence of nitrogen peroxide produced as an intermediate product, by reason of its high electron affinity.

Data are also given for the number of mols of $N_2O$ decomposed per faraday under the discharge at different exciting voltages. This quantity increases with the voltage and then reaches a maximum; the efficiency decreases subsequently. Essentially, the remarks apply to the velocity of the change under the above conditions. Data are also given for the influence of temperature from 100°C. low down to the liquid air temperatures.

## 47. On theories of adsorption indicators.

S. G. CHAUDHURY *and* M. K. INDRA, Calcutta.

The theories of Fajans and Kolthoff on the mechanism of the action of adsorption indicators in argentometric titrations have been shown to be untenable, by measuring the c.v. of the colloidal silver halide particles with and without the indicators, eosin, fluorescein and methyl violet, under the exact conditions of titration.

A new theory based on the conception of co-precipitation has been advanced. The main characteristic of this theory is that for an ideal titration (i) the solubility of the indicator compound (formed by combination of the indicator ion with either cation or anion as the case might be) should be equal to the solubility of the precipitate formed as a result of the reaction between the two precipitants, (ii) the activity of the indicator (i.e. indicator ion) taken should be equal to the activity of the anion or cation (as the case might be) in solution present after the precipitate (colloidal) is formed as a result of the reaction between equivalent quantities of the precipitants.

## 48. On hydrous oxide hydrosols and gels.

A. GANGULI, Chandernagar.

Freshly prepared sols and gels of hydrous oxides are truly amorphous. These consist of long chain complexes in accordance with the view of the author on the amorphous state developed in a previous paper. During the course of ageing and desiccation amorphous substances gradually pass to the polycrystalline and finally to the macrocrystalline forms.

Thixotropy, gelation, high viscosity, swelling of gels and X-ray structure find ready explanation on the above view.

## 49. Physico-chemical investigations on rice.

B. S. RAO, Bangalore.

From investigations carried out in this laboratory, it is concluded that rice is to be looked upon as a colloidal system intermediate between lyogel and a xerogel. During the last four weeks before harvesting of the paddy, syneresis takes place and water is exuded by rice. Application of 'Moist heat' at 60°–65°C. to freshly harvested paddy hastens the syneresis and promotes the xerogel state and a development of capillary spaces. Paddy treated in this way can be husked without causing disintegration of the rice grains and the rice obtained gives normal values for 'swelling'. Paddy is usually stored for three to six months before being husked. The physico-chemical changes that take place during this storage are discussed.

## 50. Activation of Fuller's earth.

B. S. KULKARNI *and* S. K. K. JATKAR, Bangalore.

Acting on our postulate that the activation of Fuller's earth is due to the formation of hydrogen zeolite in the body of the earth, we have studied the effect of electrodialysis and electrolysis on the Fuller's earth. From the results so far obtained, it has been noticed that the Fuller's earth is activated when subjected to such treatment and that the sodium contained in the original earth is removed and substituted by hydrogen. This method will obviate the very expensive method of activation by hydrochloric acid.

## 51. Influence of magnetic field on adsorption.

S. S. BHATNAGAR, P. L. KAPUR, *and* P. SHEEL, Lahore.

Influence of magnetic field on the adsorption of $NiSO_4$, $MnCl_2$ and $KMnO_4$ by activated carbon has been studied. Increase in adsorption in the field has been observed in the case of $KMnO_4$ whereas decrease has been observed in the case of $NiSO_4$ and $MnCl_2$. Amount adsorbed in the magnetic field has been found to be influenced by the field strength as well. The results are in agreement with the results obtained by Bhatnagar *et al.* for the velocity of reaction in a magnetic field.

## 52. Adsorption by precipitates.

N. A. YAJNIK, P. L. KAPUR, *and* M. M. SINGH, Lahore.

The adsorption of various ions ($Fe(CN)''''_6$ ; $Fe(CN)'''_6$ ; $CN'$ ; $NO'_3$ ; $ClO'_3$ ; $MnO'_4$ ; $SO''_4$ ; $IO'_3$ ; $Cl'$ ; $Br'$ ; $I'$) by the precipitated hydroxides of copper, bismuth, zinc and magnesium has been studied.

From the results of the present series of investigations, we find the order of adsorption of various ions expressed in milli-moles per gm. of the adsorbent is :

(i) For copper hydroxide :

$$SO''_4 > ClO'_3 > NO'_3 > CN' > Br' > Cl' > I' > MnO'_4 > IO'_3$$

(ii) For bismuth hydroxide :

$$CN' > Cl' > Br' > I' > NO'_3 > IO'_3 > SO''_4 > MnO'_4 > Fe(CN)''''_6 > Fe(CN)'''_6$$

(iii) For zinc hydroxide :

$CN' > SO''_4 > NO'_3 > MnO'_4 > IO'_3 > Fe(CN)''''_6 > Cl' > Br' > I' > Fe(CN)'''_6$.

(iv) For magnesium hydroxide :

$SO''_4 > NO'_3 > CN' > Fe(CN)'''_6 > Fe(CN)'''_6$

In general the order of the adsorptive power is

$Zn(OH)_2 > Bi(OH)_3 > Cu(OH)_2 > Mg(OH)_2$.

## 53. Neutral salt effect on the adsorption of acids by charcoal.

H. K. ACHARYA *and* N. K. RAY, Calcutta.

The adsorption by activated sugar charcoal and commercial charcoal of hydrochloric, benzoic, salicylic, succinic, malic, tartaric, nitrobenzoic, benzol sulphonic and citric acids from their 0·01N solutions in absence and in presence of different concentrations of NaCl and $BaCl_2$ has been studied. The pH values of the acid solutions before and after adsorption have been compared and also those of acid solutions having the same concentration as the end concentraiton of the acids and containing the salts in the same concentration as used in the adsorption experiments have been measured.

It has been found that the adsorption of the acids increases regularly with increasing concentration of the salts, NaCl being more effective than $BaCl_2$. The adsorption of the acids in the absence of the salts and the relative increment in their presence are greater for the commercial charcoal than those for the sugar charcoal. The relative increment in adsorption depends, however, on the adsorbability of the acids. The adsorbability of the acids studied lies in the order : benzoic > salicylic > succinic > malic > tartaric > nitrobenzoic > benzosulphonic > citric acid.

The results have been discussed on the basis of the variation of the pH values of the solutions and also on the neutral salt effects on the activity, solubility, hydration and surface tension of the acid solutions.

## 54. On the nature of inter-micellary liquids.

S. K. CHAKRABERTTY, D. N. GHOSH, *and* P. B. GANGULY, Patna.

Colloidal solutions of silver, copper, arsenic sulphide, aluminium hydroxide and vanadium pentoxide were prepared. Each of the solutions was filtered free from particles by means of a membrane ultra-filter and also by electro-dialysis. The pH of the original colloids and also of the inter-micellary liquids obtained by the above processes were carefully measured. A glass electrode was used, the potential being fed to the grid of a 'pleotron' space charged tube and measured with the help of a Tinsley potentiometer. In another series of experiments small amounts of acid were added to the colloid and the pH of the acidified sol and the inter-micellary liquids were again determined. In every case a small but distinct change was observed. The results are discussed in the light of previous work on the subject by Mukherji and by Pauli.

## 55. 'Zonal effect' in the variation of opacity during electrolytic and mutual coagulations of colloid arsenious sulphide and ferric hydroxide.

S. S. JOSHI *and* KRISHNA CHANDRA, Benares.

It has been established by the senior author, from viscometric and opacity measurements, that contrary to the mechanism contemplated by Smoluchowski in his classical theory for the kinetics of coagulation, this change is not time-continuous, but proceeds 'zonally', at any rate in the slow region. The data in the present paper confirm the above finding

employing the method of measuring change of opacity for both monochromatic and white light for slow coagulations of the above sols, which have had perhaps the longest usage in the studies of these phenomena, the turbidity opacity test being the oldest criterion of the occurrence of the coagulation.

## 56. Ageing of surfaces of solutions III. Effect of concentration on activated accumulation of solute molecules at surfaces of solutions.

K. S. GURURAJA DOSS, Bangalore.

The effect of concentration on the rate of activated accumulation at the surfaces of solutions has been studied. The results indicate (1) that the solute molecules at the surface are probably whipping and whirling about whenever there is free space available, and (2) that the benzopurpurin molecules tend to get associated at higher concentrations.

The significance of certain new features of the surface tension-time curves of the more dilute solutions has been discussed.

## 57. Studies on the formation of periodic precipitates—$PbI_2$ rings in agar and condition of $PbI_2$ when precipitated in presence of agar.

R. B. DALELA *and* A. C. CHATTERJI, Lucknow.

Formation of lead iodide rings in agar gel of different brands has been studied.

The regularity and the prominence of the rings increased as the concentration of the lead iodide decreased while concentration of the diffusing electrolyte remained the same.

The distance between two consecutive rings at an equal distance from the top increased as the concentration of the diffusing electrolyte was decreased.

Amount of lead iodide present as ions has been calculated at different concentrations varying from N/500 to N/50 in agar, gelatine and water (from electric conductivity experiments). A comparison of these results indicates that the condition in which lead iodide is present in agar and gelatine when freshly formed so long as the solution is colourless is not materially different from that in water. In other words agar and gelatine do not show any indication of possessing any special power of inducing supersaturation.

The percentage of lead iodide present as ions is slightly greater in gelatine than in agar. This may be due to the more acidic nature of gelatine gel (pH 5·4–5·7) than that of the agar gel (pH 6·25).

## 58. Investigations on stearic acid hydrosols.

S. MUKHERJEE, Calcutta.

The interactions of colloidal solutions of stearic acid with bases, neutral salts and hydrolysable salts have been studied. The titration curves of the sols with $Ca(OH)_2$ and $Ba(OH)_2$ are similar. After an initial rise the pH remains unchanged over a range and finally shows a sudden rise. The total acidity calculated at the inflexion point agrees with the analytical concentration of the acid. Titration curves with NaOH resemble that of a weak monobasic acid and the final inflexion point occurs at the neutralization point. Using $NH_4OH$ the final inflexion does not appear. Calculations of buffer capacity show a departure from the behaviour of a weak acid in true solution.

The hydrogen ion activity of the sol increases on interaction with $BaCl_2$ and $CaCl_2$ and very slightly with KCl.

The results have been shown to correspond to the behaviour of a heterogeneous system. Ba++ or Ca++ ions are adsorbed on the stearate ions on the surface of the particles to form ion pairs which subsequently split off and form separate solid phases. The whole of the acid is thus enabled to react. The particles gradually dissolve on interaction with NaOH or $NH_4OH$. The special features of the variations in the buffer index during titration with alkali met with in such systems have been discussed.

## 59. The electrochemical properties of electrodialysed silicic acid sols.

B. CHATTERJEE, Calcutta.

The changes produced by electrodialysis on the electro-chemical properties of silicic acid sols, purified by prolonged dialysis, have been studied. In contrast to the observations of Rabinowitsch and Kargin (Trans. Faraday Soc., *31*, 1935), the acidic character of silicic acid sols does not vanish on electrodialysis; on the contrary the electrodialysed sols, although having lower silica contents, have lower pH values and show stronger acid character. The titration curves of electrodialysed sols with dilute bases have sharper inflexion points. It has been shown that the changes in the nature of the titration curves, brought about by electrodialysis, are not due to the effect of dilution. Titration curves of the electrodialysed sols with NaOH and $Ca(OH)_2$ solutions show points of inflexion at the same concentrations of added bases but the NaOH curve is steeper in the corresponding regions than the $Ca(OH)_2$ curve. A considerable amount of acid is liberated by the action of neutral salts on electrodialysed silicic acid sols, the effects of Ba++ and Ca++ being practically the same. The ultrafiltrates of the electrodialysed sols are practically neutral. It is shown that silicic acid sols do possess acid character due to mobile hydrogen ions in the double layer associated with the colloidal particles.

## 60. Discrepancies between conductivity and activity measurements with colloidal solutions of hydrogen clays.

R. P. MITTRA, Calcutta.

Marked discrepancies have been observed between the actual specific conductivities of colloidal solutions of hydrogen clays and those calculated from their activity data. The actual conductivity is even less than that due to the hydrogen ions alone calculated from their activity determined by electrometric measurements using glass and hydrogen electrodes in conjunction with calomel half elements. These hydrogen ions, therefore, though registering their activity on the above reversible electrodes, do not take part in the conduction of electricity in the usual manner. This observation shows an anomalous difference between the conductivity and activity coefficients.

## 61. Change in the absorption limit during the electrolytic coagulation of colloid manganese dioxide.

A. PURUSHOTHAM, Benares.

Following a previous observation, we have examined the changes in the absorption spectrum during the coagulation of colloidal $MnO_2$ with particular reference to the use of mercurous sulphate as a coagulant and obtained well marked changes in the absorption band in the visible. It was observed that the shift during coagulation occurred, in the main, in the short wave region. The absorption limit on the red side was observed to be sensibly constant during a number of coagulations. Details

are given for the variation of the range of absorption as a function of the colloid and coagulant concentrations and like factors.

## Organic and Biochemistry

### 62. A study of the velocity of decomposition of some aliphatic cyanides.

D. D. GHARPURE *and* D. D. KARVE, Poona.

The velocity of the decomposition of acetonitrile, propionitrile, butyronitrile, and normal and *iso*-valeronitrile by sulphuric acid at 50°C has been determined. The proportion of amide and ammonium salt formed has been estimated separately and the effect of changes of concentration of the acid has also been studied.

### 63. Velocity of hydrolysis of butyl acetate and iso-amyl acetate in heterogeneous systems.

V. L. MEHENDALE *and* D. D. KARVE, Poona.

The hydrolysis of the above two esters dissolved in xylene and toluene by aqueous hydrochloric acid has been studied with respect to the effect of factors like speed of shaking, concentrations of the reacting substances, etc. The general conclusion reached is that these reactions take place mainly at the surface of contact, though owing to the liberation of the butyl and iso-amyl alcohols a slight proportion of the ester dissolves in the aqueous phase and a homogeneous reaction also takes place simultaneously.

### 64. Velocity of hydrolysis of some aromatic acid chlorides in heterogeneous systems.

K. K. DOLE *and* D. D. KARVE, Poona.

In continuation of previous work on the hydrolysis of benzoyl chloride (Karve and Dole, *Proc. Ind. Sc. Cong.*, 1937) the following acid halides have been investigated :

*o*-chloro-, *m*-chloro-, *o*-bromo-, *o*-ido-, *o*-nitro- and *m*-nitrobenzoyl chlorides, cinnamoyl chloride, phthalyl chloride and benzoyl bromide.

The following acid chlorides in which the solid acid separates out as a third phase have also been studied :

*p*-chloro-, *p*-bromo-, *p*-nitro-, 3·5-dinitro-benzoyl chlorides and anisoyl chloride.

From a detailed study of these heterogeneous reactions, it has been concluded that in most of these reactions the heterogeneous part of the reaction predominates and the homogeneous part, due to the very slight solubility of the acid chlorides in water, is negligible.

### 65. Synthesis and resolution of α-ethoxy stearic acid.

(MISS) P. DEVI *and* P. RAMASWAMI AYYAR, Bangalore.

This substance figuring in the title has been prepared in 80 per cent yield by the action of sodium ethoxide on α-bromo-stearic acid derived from natural stearic acid. It melts at 58-59°C and, after resolution by means of brucine, the dextro-isomer has $(\alpha)\ 25° = +9{\cdot}7°$.

### 66. Synthesis of $\alpha\beta$-eicosenoic acid.

(Miss) P. Devi *and* P. Ramaswami Ayyar, Bangalore.

By the action of sodium ethoxide on $\alpha$-bromo-eicosanic acid derived from natural eicosanic acid, one isomeric form of the above acid (m.p. 64-65°C) is formed in about 15 per cent. yield. The main product is $\alpha$-ethoxy-eicosanic acid (m.p. 62-63°C ; ethyl ester m.p. 23-24°C).

### 67. Relations between chemical activity and absorption in the ultra-violet of the chloro derivatives of the amides of malonic acid.

Mme. Ramart, K. G. Naik, *and* C. M. Mehta, Baroda.

In the present study it is expected to throw some light on the relationship between the chemical activity of the chloro derivatives of the various substituted amides of malonic acid, of the type : $Cl_2 : C : (CONHR)_2$, $Cl_2 : C : (CONH_2).(CONHR)$, and $(Cl) (ClCH_2) : C : (CONHR)_2$, where R is phenyl, tolyl, etc. groups.

The following chloro derivatives were examined in the ultra-violet and their absorption spectra were obtained.

(1) Dichloromalon-di-phenylamide, (2) Dichloromalon-di-*o*-tolylamide, (3) Dichloromalon-di-*p*-tolylamide, (4) Dichloromalon-di-*m*-tolylamide-dichloride, (5) Dichloromalon-di-1 : 3 : 4-xylidide, (6) Dichloromalon-di-heptylamide, (7) Dichloromalon-di-benzylamide, (8) Dichloromalon-mono-*p*-tolylamide, (9) Dichloromalon-monochloro-phenylamide, (10) Chloromethyl chloromalon-di-phenylamide, (11) Chloromethyl chloromalon-di-*o*-tolylamide, (12) Chloromethyl chloromalon-di-*p*-tolylamide.

The results of absorption spectra of the above compounds have been compared with the absorption spectra measurements of the compounds of the type $H_2 : C : (CONHR)_2$ studied by Ramart, Naik and Trivedi (*Bull. Soc. Chim.*, 1934, p. 525).

The comparison of these two corresponding sets of curves shows that the transformation of methylene group $-CH_2-$ into $-CCl_2-$ group produces a distinct change in the nature of the curves.

1. The principal band in the methylene compounds is more steep and narrow and its crest is situated between the frequency 1200 and 1300 ; whereas in the case of the chloro derivatives the band becomes broad and shallow and the crest of the principal band is situated between 1100 and 1200.

2. The secondary band in the case of methylene derivatives is feebly marked and is situated between the frequencies 1000 and 1100. This secondary band due to the presence of $CH_2$ group has disappeared in the chloro derivatives, where the $CH_2$ group is transformed into $-CCl_2-$ group.

3. It is observed that the general absorption increases as we pass from ortho to para derivatives. The bands of absorption are shifted towards the visible region in the following order : Ortho meta para.

4. The curves representing the absorption of dichloromalon-di-phenylamide and malon-di-phenylamide show a peculiar tendency to cut the curves representing their tolyl derivatives.

### 68. The velocity of saponification of the chloro derivatives of the substituted amides of the malonic acid of the type : $Cl_2 : C : (CONHR)_2$, $Cl_2 : C : (CONH_2) (CONHR)$ and $(Cl) (ClCH_2) : C : (CONHR)_2$, where R is phenyl, tolyl, etc. groups.

K. G. Naik, R. K. Trivedi, *and* C. M. Mehta, Baroda.

In order to investigate chemical activity of the chloro compounds as expressed by their velocity of saponification, the following compounds were selected for study :—

(1) Dichloromalon-di-phenylamide, (2) Dichloromalon-di-*p*-tolylamide, (3) Dichloromalon-di-*m*-tolylamide dichloride, (4) Dichloromalon-di-*o*-tolylamide, (5) Dichloromalon-di-1 : 3 : 4-xylidide, (6) Dichloromalon-di-heptylamide, (7) Dichloromalon-di-propylamide, (8) Dichloromalon-mono-*p*-tolylamide, (9) Dichloromalon monochloro phenylamide, (10) Chloromethyl chloromalon-di-phenylamide, (11) Chloromethyl chloromalon-di-*p*-tolylamide, (12) Chloromethyl chloromalon-di-*o*-tolylamide.

The above compounds were made to react with standard alcoholic potash solution and titrated with standard hydrochloric acid at regular intervals. The results were tabulated in the form of curves representing the time as abscissa and the percentage of the compound saponified as ordinate.

In compounds (2), (3) and (4) the augmentation of the velocity of saponification proceeds as ortho meta para. This could be explained if we were to assume that in solution the substances exist in a condition of equilibrium expressed in the following way : RNH. CO.CH : C : (OH) (NHR) RNH.CO.$CH_2$.C (: NH) (OH) R.NH.CO.$CH_2$.CO.NHR.

The velocity of saponification depends upon the nature of the radical attached to the saponifiable imino -NH- grouping. It also depends upon the position of the methyl group with regard to the saponifiable imino group.

## 69. The velocity of reduction of the chlorines substituting the hydrogens of the reactive methylene group -$CH_2$- in the compounds of the type $Cl_2$ : C : $(CONHR)_2$, where R is phenyl, tolyl, etc. groups.

K. G. Naik, R. K. Trivedi, *and* C. M. Mehta, Baroda.

The velocity of reduction of the chlorine atoms was studied by treating the following compounds by means of hydriodic acid generated through the action of HCl on KI (Kurt Meyer, *J.C.S.*, 1921, *119*, 951, 305).

(1) Dichloromalon-di-phenylamide, (2) Dichloromalon-di-*p*-tolylamide, (3) Dichloromalon-di-*m*-dichloro-tolylamide, (4) Dichloromalon-di-*o*-tolylamide, (5) Dichloromalon-di-1 : 3 : 4-xylidino, (6) Dichloromalon-di-*b*-dichloronaphthylamide, (7) Dichloromalon-di-heptylamide, (8) Dichloromalon-di-propylamide, (9) Dichloromalon-di-benzylamide, (10) Dichloromalon-monochlorophenylamide, (11) Dichloromalon-mono-*p*-tolylamide, (12) Chloromethyl chloromalon-di-phenylamide, (13) Chloromethyl chloromalon-di-*p*-tolylamide, (14) Chloromethyl chloromalon-di-*o*-tolylamide.

The velocity of reduction of chlorines was represented by obtaining the curves by plotting the time of heating along the abscissa and the percentage reduced along the ordinate. It was observed from the nature of the curves of the above compounds that the velocity of reduction goes on increasing in series from compounds (1) to (5). This is attributed to the nature of the groups attached to the carbonyl groups between which the $CCl_2$ complex is situated as well as to the insertion and the position of the methyl groups in the phenyl nucleus. In each case the velocity of reduction is considerably lowered when fifty per cent. of the total chlorine is reduced.

The curves of the compounds (7), (8) and (9) indicate that when the radicals attached to the carbonyl group carry aliphatic chain the velocity of reduction is increased. If the chain is shorter the velocity of reduction is decreased.

The compounds (10) and (11) show a drop in the velocity of reduction which is due to the presence of only one heavy radical in the complex.

The remarkable decrease in the velocity of reduction of the compounds (12), (13) and (14) is attributed to the presence of the -$ClCH_2$- grouping.

## 70. Interaction of phenylhydrazine with the halogen derivative of the substituted amides of malonic acid.

K. G. NAIK, R. K. TRIVEDI, *and* C. M. MEHTA, Baroda.

In order to study the labile nature of the chlorine atoms substituting the hydrogens in the reactive methylene group $-CH_2-$, the interaction of phenylhydrazine with the compounds mentioned below was investigated.

(1) Dichloromalon-di-phenylamide, (2) Dichloromalon-di-*o*-tolylamide, (3) Dichloromalon-di-*p*-tolylamide, (4) Dichloromalon-di-1 : 3 : 4-xylidide, (5) Dichloromalon-di-*m*-dichloro-tolylamide, (6) Dichloromalon-mono-chlorophenylamide, (7) Dichloromalon-mono-*p*-tolylamide, (8) Chloromethyl chloromalon-di-*o*-tolylamide, (9) Chloromethyl chloromalon-di-*p*-tolylamide.

All the above compounds reacted with phenylhydrazine yielding their respective hydrazone derivatives. The compounds (1), (2), (3) and (4) gave rise to the general type $C_6H_5NHN : C : (CONHR)_2$, while compounds (5) and (6) reacted with phenylhydrazine yielding the compounds in which the chlorines in the nucleus remained unaffected.

The compounds (8) and (9) reacted with phenylhydrazine in a similar way giving a three-membered ring (N-anilino ethylenimide dicarboxylanilide).

All the above hydrazone compounds are found to be very stable and resist boiling with water and alcohol.

## 71. The additive reactivity of olefines, Part I. Some preliminary observations on the addition of cyanoacetamide and malonic ester to $\alpha : \beta$ unsaturated ketones.

S. V. ANANTAKRISHNAN *and* CHITTARANJAN BARAT, Calcutta.

The influence of substituents on the additive reactivity of the ethylenic linkage of $\alpha : \beta$ -unsaturated ketones has been discussed in the light of theories developed by Ingold and co-workers. The ratio of the velocity constants in the addition re-reaction between such ketones and cyanoacetamide have been calculated from the yields on the assumption of a bimolecular reaction and this 'reduced velocity' has been used for purposes of comparison.

## 72. Action of sodium acetate and acetic anhydride on $\beta$-aryl-glutaconic acids.

G. R. GOGTE, Bangalore.

By the action of acetic anhydride and fused sodium acetate, at higher temperatures, $\beta$-(2-methoxy-5-methyl-phenyl)-glutaconic acid gives a compound, m.p. 168° C. ($C_{17}H_{16}O_6$). This is supposed to be a glutaconyl acetic acid of the C-acetyl-$\beta$-(2-methoxy-5-methyl-phenyl) -glutaconic anhydride, m.p. 126°C., as it can be synthesized from the latter by the action of acetic anhydride and fused sodium acetate. Further this compound, m.p. 168°C. gives a neutral oil by the action of hydrochloric acid, which when hydrolysed by caustic alkali, furnished the ketonic acid, m.p. 101°C. (decomp.) (described in an earlier abstract). By the action of caustic alkali, this compound, m.p. 168°C, produced a hydroxy-acid, m.p. 212°C. (decomp.); a neutral product, m.p. 82°C. and two acids m.p. 177°C. (decomp.) and 170°C.(decomp.). The constitutions of these products are under investigation.

## 73. C-acylation of β-aryl-glutaconic anhydrides.

G. R. GOGTE, Bangalore.

By the action of acetyl chloride and pyridine, β-(4-methoxy-phenyl)-glutaconic anhydride (m.p. 160°C) has been found to give an acetyl derivative, m.p. 130°C. The C-acetylation here has been proved by the transformation of this derivative into a ketonic acid, m.p. 125°C (decomp.), which was found identical with the one described by Limaye and Bhave (*J. Univ. Bombay*, *2*, part II, 82). The derivative titrates as a monobasic acid (*cf.* C-acetyl-acetoacetic ester) and gives violet ferric reaction. β-(2-methoxy-5-methyl)-phenyl glutaconic anhydride (m.p. 117°C) gives a similar C-acetyl derivative, m.p. 126°C, from which a ketonic acid, m.p. 101°C (decomp.), has been isolated. The neutral ketone b.p. 177°/36 mm. obtained by decarboxylating this ketonic acid, gave, on oxidation with hypobromite, 2-methoxy-5-methyl-β-methyl-cinnamic acid, m.p. 111°C, which again was transformed into 4 : 6-dimethyl coumarin, m.p. 148-49°C, by the action of concentrated sulphuric acid.

The action of benzoyl chloride and pyridine on β-aryl-glutaconic anhydride is under investigation.

## 74. Halogenation, Part XXII. Chlorination and bromination of toluene under the combined influence of sunlight and halogen carriers.

P. S. VARMA, (MRS.) P. ANNAPURNA S. RAO, *and* A. KRISHNAMURTHY, Benares.

Chlorination and bromination of toluene have been carried on exhaustively in sunlight alone or in the dark or in sunlight in presence of substances such as lithium bromide, beryllium oxide, sodium chloride, magnesium powder, magnesium bromide, aluminium dust, aluminium chloride, aluminium-mercury couple, red and yellow phosphorus, phosphorus pentachloride, phosphorus trichloride and tribromide. sulphur, chromic acid, manganese chloride, potassium permanganate, iron, ferric chloride and bromide, nickel bromide, cuprous and cupric chloride, finely divided copper, zinc dust, arsenic trichloride, selenium, bromine, yttrium nitrate, zirconium nitrate and oxide, molybdic acid, freshly precipitated silver oxide, antimony and antimony trichloride, iodine, lanthanum chloride, didanium nitrate, cerium chloride, mercury and red oxide of mercury, thorium oxide and chloride and uranium nitrate, etc.

On account of their effect on chlorination and bromination, the above substances can be divided into the following four groups :—

1. Those that have no effect at all on chlorination and bromination, i.e. the products obtained being the same as those obtained in sunlight alone.
2. Those that facilitate the production of only *p*-substituted nuclear compounds with a certain quantity of the side-chain substituted halogen derivatives.
3. Those that produce both *o*- and *p*-substituted nuclear compounds, the *p*-substituted derivative predominating in some cases and the *o*-substituted one in others.
4. Those that induce both *o*- and *p*-substituted nuclear derivatives as well as side-chain substituted ones.

Results obtained in chlorination and bromination are not identical, there being considerable differences in the nature of the products obtained in the two cases.

## 75. γ-Substitution in the resorcinol nucleus, Part II. The Gattermann reaction on resacetophenone.

H. A. Shah *and* R. C. Shah, Bombay.

Resacetophenone does not undergo the Gattermann reaction under the usual conditions. However, the application of the modified method of Shah and Laiwalla (*Ind. Sci. Cong. Abst.*, 1937, 24; *Current Sci.*, 1936, 197) for the introduction of the aldehydo group in the γ-position into methyl β-resorcylate, was successful. The Gattermann reaction thus carried out with aluminium chloride dissolved in dry ether as solvent, gave a high yield of the ketone-aldehyde 2 : 4-dihydroxy-3-aldehydo-acetophenone (I), the aldehydo group entering the γ-position, as in the case of methyl-β-resorcylate. Various derivatives and related compounds have been prepared from (I). Synthesis of coumarino-chromones and similar heterocyclic compounds from (I), which appears to be well adapted for this purpose, is under progress.

2-acetyl resorcinol by the modified Gattermann reaction gives the corresponding aldehyde, 2 : 4-dihydroxy-3-acetyl-benzaldehyde.

## 76. γ-Substitution in the resorcinol nucleus, Part III. Synthesis of 2-benzoyl-resorcinol.

V. R. Heeramaneck *and* R. C. Shah, Bombay.

Benzanilide imidochloride reacts with methyl-β-resorcylate in the presence of aluminium chloride to give the anil-hydrochloride of methyl-2 : 4-dihydroxy-3-benzoyl-benzoate (I) which on treatment with alcoholic HCl gives methyl-2 : 4-dihydroxy-3-benzoyl-benzoate (II). (II) on hydrolysis with cold alkali gives the corresponding free acid (III) which on decarboxylation afforded *p*-benzoyl-resorcinol (IV), m.p. 135°C. (IV) is also obtained directly from (II) by boiling with alkali, hydrolysis and decarboxylation taking place in one stage. Limaye has previously synthesized (IV), m.p. 136°C, by the action of alkali on 7-hydroxy-4-methyl-8-benzoyl-coumarin (*Ber.* 1934, *61*, 12).

## 77. On anacardic acid, Part III.

P. Parameswaren Pillay, Trivandrum.

Anacardic acid, the chief constituent of the pericarp of the Cashewnut has a salicylic acid fragment with a long straight $C_{15}H_{27}$ side chain in the ortho-position to the carboxyl. The acid was reduced with sodium and alcohol and also distilled with zinc. Nitration, oxidation with hydrogen peroxide, the effect of heat on its ammonium salt and the condensation induced by thionyl chloride, were also studied.

## 78. Synthesis of ortho-cyanaldehydes, Part I.

S. N. Chakravarti *and* K. Ganapati, Agra.

Attempts to synthesize ortho-cyanaldehydes, none of which have yet been synthesized, from the corresponding *o*-amino-aldehydes, *o*-amino-aldoximes, *o*-amino-acetals and *o*-amino Schiff's bases through the aid of Sandmeyer's reaction were all unsuccessful. During the course of these experiments an excellent method of preparing *o*-amino-aldoximes was discovered. *O*-amino-aldoximes can be diazotised in concentrated hydrochloric acid solution.

*O*-cyanaldehydes can be readily synthesized but only in poor yields by the oxidation (with permanganate) of the corresponding *o*-cyan-cinnamic acids which are readily obtainable by synthesis. During these oxidations a high melting substance is always formed in every case as a main product. These substances are being investigated.

3-methoxy-6-cyan-benzaldehyde, m.p. 107°C, and *o*-cyanbenzaldehyde, m.p. 76°C, were synthesized by this method.

## 79. Halogenation, Part XXI. Direct replacement of sulphonic groups in aromatic hydrocarbons by chlorine atoms.

P. S. VARMA, N. B. PAREKH, *and* V. K. SUBRAMANIAN, Benares.

It has been possible to replace directly sulphonic groups by chlorine in aromatic hydrocarbons by heating the aromatic hydrocarbon sulphonic acids strongly with cuprous or cupric chloride and thus chloro-benzene from benzene sulphonic acid, *p*-chloro-toluene from *p*-toluene-sulphonic acid, *o*-chloro-toluene from *o*-toluene sulphonic acid, *p*-nitro-chloro-toluene from *p*-nitro-toluene sulphonic acid, *p*-chloro-*o*-nitro-toluene from *o*-nitro-toluene sulphonic acid, *m*-nitro-chloro-benzene from *m*-nitro-benzene sulphonic acid, trichloro-benzene from dichloro-benzene sulphonic acid, α-chloro-naphthalene from naphthalene-α-sulphonic acid, β-chloro-naphthalene from naphthalene-2-sulphonic acid and 6 : 8-dichloro-2-naphthylamine from 2-naphthylamine 6 : 8-disulphonic acid have been obtained. By a similar process bromo derivatives of aromatic hydrocarbons have also been prepared.

## 80. Studies in chloral amides: chloral-amide of 3-amino-salicylic acid.

N. W. HIRWE *and* M. A. WAGH, Bombay.

3-acetylamino-salicylamide was condensed with chloral to the corresponding chloral amide. Acetyl and benzoyl derivatives were prepared. Sulphuric acid did not dehydrate this compound to an oxazine derivative, as in the case of 5-amino acid, but the same was obtained when the chloral amide was treated with acetic anhydride in an alkaline medium. The compound could not also be hydrolysed with aqueous ammonia into an α-amino-chloral-3-amino-salicylamide.

## 81. Studies in chloral amides: Chloral amide of 5-amino-salicylic acid.

N. W. HIRWE *and* K. N. RANA, Bombay.

5-acetylamino-salicylamide was condensed with chloral, giving the corresponding chloral-amide. Various derivatives, such as acetyl, benzoyl and methoxy, of this chloral-amide have been prepared. It gave a meta-oxazine compound on dehydration with concentrated sulphuric acid. The oxazine compound on treatment with acetic anhydride gave an acetyl derivative suggesting the presence of a tautomeric hydrogen ; hydrochloride of the oxazine could not be obtained, thus confirming the existence of the hydroxy group. Attempts were made to break the oxazine ring at the oxygen-linkage with a view to obtain an α-amino group by hydrolysis with strong ammonia: shaking with liquor ammonia (D. 0·888) had no effect, but on heating the molecule hydrolysed to give the starting acid ; on passing a current of ammonia in a warm alcoholic solution of the substance a base was obtained, the hydrochloride of which analysed as $C_{30}H_{40}O_{10}N_7Cl_4$.

Further work is in progress.

## 82. Nitration of *m*-methoxy-cinnamic acid.

S. N. CHAKRAVARTI, K. GANPATI, *and* S. ARAVAMUDHACHARI, Agra.

4-nitro-3-methoxy-cinnamic acid, m.p. 296°C, is formed as the main product of nitration of *m*-methoxy-cinnamic acid. The constitution of the nitro compound was established by its oxidation to 4-nitro-4-methoxy-benzaldehyde and 4-nitro-3-methoxy-benzoic acid, and by synthesis. The formation of 4-nitro-3-methoxy-cinnamic acid as the main product of nitration is a matter of considerable interest and is rather anomalous and contrary to the expectations of the current theories.

6-nitro-3-methoxy-cinnamic acid, m.p. 227°C and 2-nitro-3-methoxy-cinnamic acid m.p. 265°C which were also formed as bye-product during the nitration were also synthesized. All the corresponding hydroxy nitrocinnamic acids have also been synthesized, which, curiously enough, all melt lower than the corresponding methoxy compounds.

During the course of these investigations it was found that much of the older work on nitration of *m*-hydroxy-cinnamic acid and 3-methoxy-cinnamic ester requires revision and correction.

## 83. The condensation of aldehydes with amides, Part I. The condensation of salicylaldehyde.

K. C. PANDYA *and* S. T. SINGH, Agra.

Condensations of aldehydes with amides have been studied by a large number of workers, in some cases with the help of catalysts, in others without them. No attempt appears to have so far been made to observe whether the catalyst could be traces of organic bases, like pyridine, found so very useful in condensations of aldehydes with malonic acid by Pandya and co-workers. Nor has any one apparently studied the possibility of condensations of salicylaldehydes in this manner.

It has been shown in this paper that salicylaldehyde condenses with formamide, acetamide, benzamide and phenyl-acetamide, equally well, when the sodium acetate of earlier workers (Cebrian, *Ber.* 1898, *31*, 1592 ; Titherley and Harples, *J.* 1908, *93*, 1933) is replaced by any of the usual organic bases in traces, or even when no base is used at all. The products obtained here are identical with those reported by earlier workers, but are much cleaner (*cf.* Gupta, *J.*, 1921, *119*, 298). The earlier workers have not mentioned yields, but a comparison has been made by repeating their experiments, when it is found that the yields in the present case are not only very much higher, but are occasionally quantitative.

The structures of the resulting compounds are discussed.

## 84. The condensation of aldehydes with amides, Part II. Condensation of cinnamaldehyde.

R. K. MEHRA *and* K. C. PANDYA, Agra.

There is only one condensation so far reported, and that is of this aldehyde with phenylacetamide by Gupta (*J.*, 1921, *119*, 298), who by merely heating the two together for 2 hours at 160–170°C obtained cinnamylidene-bis-phenylacetamide. The yield is not mentioned, but on repeating his experiment, the authors obtained an yield of about 15% only. It increased slightly only, to 18%, when a trace of pyridine was used as a catalyst. In condensations with acetamide and with benzamide, suitable alterations in the conditions of the experiments improved the yield, which came up to about 50%. Analysis showed the products to be of a similar composition to above.

Condensations with formamide gave a product in very good yield, but the exact composition of it is under investigation.

Propionamide also condenses well.

## 85. The condensation of aldehydes with malonic acid in the presence of organic bases, Part X. The condensation of resorcylaldehyde.

K. C. PANDYA *and* S. T. SINGH, Agra.

The condensation of aromatic aldehydes with malonic acid in the presence of organic bases in traces has been found to be often affected by the presence of a hydroxy group in the nucleus, particularly in the ortho-position (*vide* earlier papers, *Proc. Ind. Acad. Sci.* and *Proc. Ind. Sci. Cong.*). In the present case of resorcylaldehyde, 2 : 4-dihydroxy-benzaldehyde (I), there is an aromatic aldehyde with two hydroxy groups, and one of them is in an ortho position to the aldehyde group.

Resorcylic aldehyde condensed with malonic acid in the presence as well as in the absence of an organic base in traces, though the product in the first case was umbelliferone and in the latter case was umbellic acid (2 : 4-dihydroxy-cinnamic acid). The yields, however, were small, ranging between 24 and 37%. This may be due to the presence of a second hydroxy group, as was expected.

## 86. The condensation of aldehydes with malonic acid in the presence of organic bases, Part IX. The condensation of $\beta$-hydroxynaphthaldehyde or 2-hydroxy-naphthaldehyde—(I).

K. C. PANDYA *and* T. A. VAHIDY, Agra.

In the earlier papers on the study of the condensation of aromatic aldehydes with malonic acid in the presence of organic bases, a diminished yield of the condensation product has often been observed when a hydroxyl group has been present in the benzene ring, particularly in the ortho-position. 2-hydroxy-naphthaldehyde was prepared from $\beta$-naphthol by the well known modification of Gattermann's method, and the condensation with malonic acid in the presence of traces of pyridine, lutidine and $\alpha$-picoline was found, on heating at 105–110°C for six hours, to give almost quantitative yields. Even when no base was used, the condensation took place and gave, under the conditions described above, over 60% yield.

It appears therefore that in a naphthalene ring, in the position 2 : 1, the hydroxy group does not exert the same obstructive influence as it does in salicylaldehyde.

The product in all the above cases was 5 : 6-benzocoumarin-carboxylic acid, m.p. 81°C, while by Perkin's method benzocoumarin and small amounts of $\beta$-naphthyl-acrylic acid have been obtained by other workers.

## 87. Oxidation of naphthalene in the vapour phase.

J. K. CHOWDHURY *and* M. A. SABOOR, Dacca.

Naphthalene has been oxidised with air in the presence of different catalysts. Mixed oxides of tin and vanadium have given the best results in the oxidation of naphthalene to phthaleic anhydride under the following conditions :—

| | |
|---|---|
| Diam. of catalyst tube (glass) | 1·5 cm. |
| Catalyst space | 6·3 c.c. |
| Air ratio | 3 times theoretical. |
| Time of contact | 0·32 sec. |
| Carburettor temp. | 172°C. |
| Temp. of catalyst bed | 290°C. |

About 60% of the naphthalene used was attacked and the yield of phthaleic anhydride was 90% of theoretical.

The following intermediate products have been identified: naphthol, 1–4 naphthaquinone, phthalic anhydride, benzoic acid and maleic acid. The mechanism of the oxidation is explained with the help of hydroxylation theory, the *p*-dihydroxy compounds being supposed to be formed at a high temperature.

## 88. Studies in the naphthalene series, Part I. The synthesis of alkyl naphthols.

R. D. DESAI, A. KAMAL, M. AKRAM, *and* ABDUL HAMID, Aligarh.

2-acetyl-$\beta$-naphthol and 2-propionyl-$\alpha$-naphthol, give on Clemmensen reduction 2-ethyl-$\alpha$-naphthol and 2-propyl-$\alpha$-naphthol. Methods for the preparation of 4-acetyl-$\alpha$-naphthol and 4-propionyl-$\alpha$-naphthol in good yield have been worked out, and these yield on reduction 4-ethyl-$\alpha$-naphthol and 4-propyl-$\alpha$-naphthol. The bromination and nitration of those acylnaphthols as well as alkylnaphthols have been studied, and the constitutions of the resulting products have been elucidated.

## 89. Studies in the naphthalene series, Part II. The synthesis of 2 : 4-diacyl-$\alpha$-naphthols.

R. D. DESAI, M. AKRAM, *and* ABDUL HAMID, Aligarh.

Various 2 : 4-diacyl-$\alpha$-naphthols have been prepared by the action of acylchlorides on 2-acyl-$\alpha$-naphthol in presence of anhydrous zinc chloride or on 4-acyl-$\alpha$-naphthol in presence of anhydrous aluminium chloride. Bromination as well as nitration revealed the labile character of the acyl group in the 4-position. The same acyl group can also be replaced by hydrogen by the action of anhydrous aluminium chloride or zinc chloride. With the object of determining the constitution of the products obtained by brominating and nitrating 2 : 4-diacyl-$\alpha$-naphthol, chromones have been prepared; and these have been degraded to various 1-hydroxy-2-naphthoic acid derivatives.

## 90. Studies in the naphthalene series, Part I. Synthesis of polyhydroxy derivatives of naphthalene.

S. N. CHAKRAVARTI *and* V. PASUPATI, Agra.

An account is given of the attempts that have been made by the authors to synthesize symmetrically disubstituted and tetrasubstituted hydroxy derivatives of naphthalene, which were required for purposes of a comprehensive study of their properties and more particularly for the study of their oxidation products. Attempts were first made to synthesize 1 : 2 : 6- and 1 : 2 : 7-trihydroxy naphthalene and 1 : 2 : 5 : 6- and 1 : 2 : 7 : 8-tetrahydroxy naphthalene from the corresponding amino compounds which were synthesized for the purpose, but in none of these cases could the amino group be replaced by the hydroxy group although a variety of different conditions was tried. Next attempts were made to synthesize the required hydroxy compounds from the corresponding bromo compounds through the Grignard reaction, etc., but here again results obtained were not at all encouraging. Eventually 1 : 2 : 6- and 1 : 2 : 7-trihydroxy naphthalenes were synthesized by the following method which is being extended to the synthesis of the tetrahydroxy compounds. 2 : 7- and 2 : 6-dihydroxy naphthalenes were converted into nitroso compounds and the latter reduced to the corresponding amino compounds, which on oxidation under very careful conditions gave 6-hydroxy- and 7-hydroxy-naphthaquinones. The quinones on reduction gave the required trihydroxy naphthalenes which were also converted into the corresponding triacetyl and trimethoxy compounds. The hydroxy quinones have been nitrated and the mononitro compounds converted into the corresponding nitro-trihydroxy compounds

by reduction with sulphur dioxide and the trihydroxy compounds in their turn were converted into nitro-trimethoxy compounds. The nitrohydroxy quinones have also been directly reduced to corresponding trihydroxy amino compounds.

## 91. Synthesis of coumarins from phenols and acetoacetic esters : constitution of halogenated resorcins and orcins.

D. Chakravarti *and* S. Mukerjee, Calcutta.

Bromoresorcin (Zehenter, *Monatsh*, *8*, 293), prepared from resorcylic acid, has been shown to be 4-bromoresorcin since 6-bromo-7-hydroxy-4-methylcoumarin (m.p. 278°C), the coumarin derived from bromoresorcin by condensation with acetoacetic ester, gives 6-bromo-7-methoxy-4-methyl coumarin (m.p. 245°C) identical with the product obtained by Sandmayer's reaction on 6-amino-7-hydroxy-4-methylcoumarin, the reduction product of the nitro derivative of $\beta$-methyl-umbelliferone methyl ether. The coumarin thus obtained from bromoresorcin is different from 8-bromo-7-hydroxy-4-methylcoumarin (m.p. 251-252°C), obtained by Sandmayer's reaction on 8-amino-7-hydroxy-4-methylcoumarin, the reduction product of the nitro derivative of $\beta$-methyl-umbelliferone.

Monochloro-orcin, prepared by the action of sulphuryl chloride on orcin and monobromo-orcin (Lampartèr, *Annalen*, 1865, *134*, 258) have been shown to be 4-chloro- and 4-bromo-derivatives of orcin since they form 5-hydroxy-coumarins and not 7-hydroxy-coumarins by condensation with acetoacetic ester and its alkyl-derivatives.

These halogenated resorcins and orcins give always coumarins with acetoacetic ester and its derivatives even if the condensing agent is phosphorus pentoxide; thus the generalization made by Chakravarti (*J. Indian Chem. Soc.*, 1932, *9*, 31) holds true in these cases also.

## 92. The Pechmann condensation of methyl-$\beta$-resorcylate with $\alpha$-alkyl-acetoacetic esters.

S. M. Sethna *and* R. C. Shah, Bombay.

In continuation of the work reported last year (*Indian Sc. Cong. Abst.*, 1937, 21), methyl-$\beta$-resorcylate has been condensed with $\alpha$-methyl-, $\alpha$-ethyl-, $\alpha$-propyl- and $\alpha$-butyl-, acetoacetic esters in the presence of sulphuric acid. In each case the condensation product was a mixture of 7-hydroxy-4-alkyl-coumarin-6-carboxylic acid and the corresponding methyl ester, from which the free acid and the ester were separated pure. The constitutions of all the condensation products have been established and various derivatives prepared.

## 93. Aluminium chloride—a new reagent for the condensation of $\beta$-ketonic esters with phenols, Part I. Condensation of methyl $\beta$-resorcylate with ethyl acetoacetate.

S. M. Sethna *and* R. C. Shah, Bombay.

The authors have previously studied the condensation of methyl $\beta$-resorcylate with ethyl acetoacetate in the presence of sulphuric acid, which gave methyl 7-hydroxy-4-methyl-coumarin-6-carboxylate (*Indian Sci. Cong. Abst.*, 1937, 21). It is now found that with anhydrous aluminium chloride as condensing agent, the condensation proceeds differently with the formation of methyl 5-hydroxy-4-methyl-6-carboxylate (I), m.p. 185-186°C, in good yield and a small quantity of the corresponding 7-hydroxy compound. (I) on hydrolysis gave the corresponding carboxylic acid, m.p. 248-249°C, which on decarboxylation gave 4-methyl-5-hydroxy-coumarin, m.p. 263°C, also in good yield, whose constitution was confirmed by conversion into the methylated cinnamic acid. Limaye has recently

reported the formation of 4-methyl-5-hydroxy-coumarin in a minute yield in the Kostanecki acetylation of 2-acetyl resorcinol, itself obtained from resorcinol through a number of stages (*Rasayanam*, 1936, 45).

The unique action of aluminium chloride in the above condensation which directly affords a 5-hydroxy-coumarin derivative, instead of the 7-hydroxy compound, which is obtained with other known condensing agents is noteworthy. The work is being extended to other phenol-carboxylic acids and their esters.

## 94. Aluminium chloride—a new reagent for the condensation of $\beta$-ketonic esters with phenols, Part II. Condensation of resacetophenone with ethyl acetoacetate.

N. M. SHAH *and* R. C. SHAH, Bombay.

The condensation of resacetophenone with ethyl acetoacetate with aluminium chloride as condensing agent affords 5-hydroxy-4-methyl-6-acetyl-coumarin (I), m.p. 165°, in high yield, the condensation being analogous to that of methyl $\beta$-resorcylate, described in the previous paper. The constitution of (I) has been established and confirmed by its synthesis by the Fries transformation of 4-methyl-5-acetoxy-coumarin.

The formation of the corresponding 7-hydroxy-coumarin, 4-methyl-7-hydroxy-6-acetyl coumarin in the sulphuric acid condensation of resacetophenone with ethyl acetoacetate (Aggarwal and Dutt, *J. Indian Chem. Soc.*, 1937, *14*, 109) could not be confirmed, only unchanged resacetophenone being obtained (*cf.* Gaind, Gupta and Ray, *Current Sci.*, 1937, *5*, 646).

Further work including the condensation of other phenolic ketones and the synthesis of coumarino-chromones from (I) is in progress.

## 95. Aluminium chloride—a new condensing agent for the condensation of $\beta$-ketonic esters with phenols, Part III. Condensation of ethyl acetoacetate with simple phenols.

N. M. SHAH, S. M. SETHNA, *and* R. C. SHAH, Bombay.

The condensation of ethyl acetoacetate with various phenols in the presence of anhydrous aluminium chloride has been studied. The solvent used was dry ether in which aluminium chloride dissolves readily (cf. Shah, *Current Sci.*, 1934, 157) or nitrobenzene. In most cases, the same products are formed as with sulphuric acid as condensing agent. In some cases the yields are better than with sulphuric acid; the most remarkable example being phenol, which gives a 30–40% yield of the coumarin with aluminium chloride, whereas the yield reported in literature for phenol with sulphuric acid is only 3%.

## 96. Heterocyclic compounds, Part VI. Coumarins from resacetophenone and cyclic-$\beta$-ketonic esters.

R. D. DESAI *and* NAZIR AHMAD, Aligarh.

Resacetophenone condenses with cyclohexanone-2-carboxylate, 4-methylcyclohexanone-2-carboxylate, 5-methylcyclohexanone-2-carboxylate, 6-methyl cyclohexanone-2-carboxylate and trans-$\beta$-decalone-3-carboxylate in the presence of phosphorus oxychloride with the formation of 7-hydroxy-5-acetyl-3 : 4-cyclohexeno- or 3 : 4-cyclo-octaline-coumarins. This condensation does not take place in the presence of concentrated sulphuric acid or sodium ethoxide. The isomeric 7-hydroxy-8-acetyl coumarins have been obtained by the Fries transformation of the respective 7-acetoxy coumarins obtained by the acetylation of the coumarins from

resorcinol and respective β-ketonic esters in the presence of concentrated sulphuric acid.

## 97. Heterocyclic compounds, Part VII. Coumarins from phenols and cyclic β-ketonic esters.

R. D. DESAI *and* NAZIR AHMAD, Aligarh.

Coumarins have been obtained by condensing 4-methylcyclo-hexanone 2-carboxylate, 5-methylcyclohexanone-2-carboxylate, 6-methylcyclohexanone-2-carboxylate and trans-β-decalone-3-carboxylate with resorcinol, orcinol, phloroglucinol, pyrogallol and -naphthol in the presence of concentrated sulphuric acid. The various derivatives and other properties of these coumarins have been studied.

## 98. Heterocyclic compounds, Part VIII. Chromones from 4-ethyl-resacetophenone.

R. D. DESAI *and* SH. ABDUL HAMID, Aligarh.

Excepting the work of Wittig and his co-workers (*Annalen*, 1925, 460) on the application of the Kostanecki reaction to *o*-acyl derivatives of the cresols, no systematic work has been done. Flavones containing alkylated benzene nucleus have been found to occur in nature. Therefore, a systematic study of the synthesis of this type of chromones and flavones has been undertaken. On heating 4-ethyl resacetophenone with acetic anhydride and anhydrous sodium acetate, 7-acetoxy-6-ethyl-3-acetyl-2-methylchromone was obtained. This was converted into 7-hydroxy-6-ethyl-3-acetyl-2-methylchromone and 7-hydroxy-6-ethyl-2-methylchromone. The various derivatives of 7-hydroxy-6-ethyl-2-methylchromone have also been prepared.

## 99. Coumarin-4, brom- and 3, bromacetic acids.

B. B. DEY *and* S. SANKARAN, Madras.

A study of the reactivities of the bromine atoms in the two series has been carried out with interesting results. Although the halogen in coumarin-4, methobromides was found to be very inactive (Dey and Radhabai, *J. Indian Chem. Soc.*, 1934, *11*, 636), the corresponding hydroxymethyl- and acetoxy-methyl compounds have now been prepared.

## 100. The reactivity of the chalkone oxides.

K. D. MUDBHATKAL *and* T. S. WHEELER, Bombay.

The reactions of the oxide of *p*-tolyl-4-methoxy styryl ketone have been studied. It gave a *diketone* and a *glycollic acid* with sodium hydroxide. With hydrazine hydrate it yielded the *hydroxy pyrazoline* which with sodium ethoxide gave the *pyrazole*. The glycollic acid is converted into a desoxybenzoin by potassium chromate. The *acetoxy* and *chlorohydrin* derivatives have also been prepared.

A number of condensations of chalkones with desoxy-benzoins have also been studied.

## 101. The reactivity of the chalkones of bromopiperonal.

G. V. DESHMUKH *and* T. S. WHEELER, Bombay.

The chalkone obtained by the condensation of bromopiperonal with acetophenone gave a dibromide which with pyridine gave a *bromostyryl-ketone*. The dibromide on treatment with 2 mols of sodium ethoxide gave an *ethoxy-styryl ketone* which with HCl gave a *diketone*. The dibromide on treatment with alcoholic ammonia gave an *ammonia compound*.

Bromopiperonal and acetonaphthol were condensed to a *hydroxy chalkone*. This with sodium acetate and acetic anhydride gave an *acetoxy chalkone* which on bromination gave a *dibromide*. The hydroxy chalkone also gave a dibromide which on heating under reduced pressure gave a *flavone*. The hydroxy chalkone with alcoholic phosphorus pentoxide also gave a flavanone.

## 102. Synthesis of benzylidenebenzocoumaranones.

A. P. Khanolkar *and* T. S. Wheeler, Bombay.

Ingham, Stephen and Timple (*J.*, 1931, 895) attempted to synthesize benzocoumaranones from naphthoxyacetic acids but were unable to decide definitely the structure of the products. The new unambiguous synthesis of benzylidenecoumaranone by the action of alkali on *o*-hydroxy-phenyl-α-bromo-β-ethoxy-phenylethyl ketone (*Current Sci.*, 1937, 475) has been applied to 1-hydroxy-2-naphthyl-α-bromo-β-ethoxy-3′-4′-methylenedioxystyryl ketone and a benzylidenebenzocoumaranone obtained. The dibromides of 1-hydroxy-2-naphthylstyryl ketones are but slightly soluble in alcohol and do not readily form ethoxy derivatives; accordingly they yield naphthoflavones by Kostanecki's dibromide method. They are soluble in chloroform and on heating with a mixture of absolute alcohol and chloroform pass to the ethoxy compounds.

## 103. New syntheses of flavones.

W. A. Hutchins *and* T. S. Wheeler, Bombay.

The dibromides of *o*-hydroxyphenyl styryl ketones which ordinarily give benzylidene-coumaranones on treatment with alkali by Kostanecki's method yield flavones if directly heated.

A new synthesis of chrysin is obtained by brominating 2-hydroxy-4 : 6-dimethoxy-phenyl styryl ketone. The product is heated to give a bromo-flavone which on treatment with hydriodic acid yields chrysin.

Similarly 2-hydroxy-4 : 6-dimethoxy-phenyl-4-methoxy-styryl ketone is brominated and the product heated to give a bromo-flavone which on treatment with hydriodic acid yields apigenin.

The bromide of 2-hydroxy-4 : 6-dimethoxy-phenyl-3 : 4-dimethoxy-styrylketone is unstable, presumably because of the number of methoxy groups present. It is hoped that the use of the dinitrobenzyl ether of protocatachuic aldehyde will enable the synthesis of leuteolin to be achieved by this method.

## 104. 2-naphthyl chromones.

V. V. Virkar *and* T. S. Wheeler, Bombay.

The methyl ester of 2-methoxy-3-naphthoic acid has been condensed with 2-methoxy-acetonaphthone to give 2 : 2′-dimethoxy-3 : 1-dinaphthoyl-methane. This on treatment with cold concentrated hydriodic acid (*d.* 1·7) gives a 2-naphthyl-benzochromone.

Similarly, the methyl ester of 2-methoxy-3-naphthoic acid has been condensed with *o*-methoxyacetophenone to give 2 : 2′-dimethoxy-benzoyl-3-naphthoyl methane. The action of HI on the latter is being studied.

## 105. On the constitution of plant alkaloids. (A discourse.)

R. Robinson, Oxford.

## 106. Rottlerin.

K. S. Narang *and* J. N. Ray, Lahore.

Evidence has been adduced that rottlerin has the composition $C_{27}H_{26}O_7$. Four of the oxygen atoms occur as phenolic hydroxyl groups.

The tetramethyl ether (m.p. 144°) is not further acylated indicating that the remaining oxygen atoms are ethereal or inert. The formation of a tetrahydro derivative indicates the presence of two double bonds. Oxidation of the tetramethyl ether with hydrogen peroxide gives a substance $C_{31}H_{36}O_8$ which decomposes into benzaldehyde and other unrecognizable substances.

Hydrolysis of tetrahydrorottlerin with alcoholic hydrochloric acid gives a substance $C_{20}H_{22}O_4$, m.p. 171°C, the structure of which is discussed.

Tetramethyl rottlern reacts with nitrous acid to give a substance $C_{17}H_{19}NO_5$ (or $C_{19}H_{21}NO_6$ ?) which is being further degraded.

The structures of the different products described above have been discussed and a tentative formula for rottlerin has been advanced.

## 107. Synthetical experiments with dimethyldiazomethane, Part I. New synthesis of caronic and homocaronic acid.

P. C. GUHA *and* D. K. SANKARAN, Bangalore.

Although diazomethane and diazoacetic ester have found application in the synthesis of some monocyclic and bicyclic derivatives of compounds of the thujane group, no synthetic investigations are on record in which dimethyl-diazomethane has been used for such synthesis. Dimethyl-diazomethane has been found to react with ethyl-fumarate at -18° to give a pyrazoline compound yielding finally trans-ethyl caronate. Dimethyl diazomethane reacts similarly with diethyl glutaconate to yield homocaronic acid, which has recently been synthesized by Owen and Simonsen by a different method.

## 108. A new and direct synthesis of dihydro-isolauronolic- and iso-lauronolic acids.

P. C. GUHA *and* K. S. SUBRAMANIAN, Bangalore.

The formation of iso-lauronolic acid from derivatives of camphor such as $\alpha$-campholytic acid, camphoric anhydride, etc., involves a peculiar molecular rearrangement and therefore a direct synthesis of this acid is interesting. Ethyl dimethyl-acetoacetate reacts with ethyl-$\alpha$-bromosuccinate in presence of zinc (Reformatsky) to give a mixture of ethyl $\alpha : \alpha : \beta$-trimethyl-$\beta$-hydroxy-$\beta'$-carbethoxy adipate (I) (acid, m.p. 165-166°C) and ethyl $\alpha : \alpha : \beta$-trimethyl-$\gamma$-carbethoxy-$\beta$-butylene-$\alpha : \delta$ di-carboxylate (II). The mixture gives the latter ester (II) (b.p. 155–162°/5 mm.; acid, m.p. 239-240°C; trianilide, m.p. 235°C; anilide anil, m.p. 212°C) with $PBr_3$ in dry chloroform and undergoes cyclization with sodium in dry benzene to form among other products ethyl 1 : 1 : 2-dimethyl-$\Delta^2$-cyclopentene-5-one-3 : 4-dicarboxylate, b.p. 125–128°/3 mm. This ester is soluble in alkali, gives violet coloration with alcoholic $FeCl_3$, and does not react with semicarbazide or hydroxylamine; on hydrolysis with dil. alc. KOH it forms an unstable syrupy ketonic acid, which loses carbon dioxide on treatment with hydrochloric acid forming 1 : 1 : 2-trimethyl-$\Delta^2$-cyclopentene-5-one-3-carboxylic acid designated keto-isolauronolic acid, m.p 186-187°C, (oxime, m.p. 139-140°; semicarbazone, m.p. 225°). This on Clemmensen's reduction was expected to give isolauronolic acid, but during the reaction, the ethylenic linkage was also reduced, forming mainly dihydro-isolauronolic acid (b.p. 110–115°/20 mm.) from which isolauronolic acid has been obtained by methods already known.

(I) $(COOEt).CH_2.CH(CO_2Et).C(OH)CH_3.CMe_2.CO_2Et$

(II) $(COOEt).CH_2.C(CO_2Et): CMe. CMe_2.CO_2Et$.

109. Investigations on the nature of products obtained by the addition of diazo-compounds to conjugated double bonded systems, Part I. A new synthesis of isodehydroapocamphoric acid and a synthesis of $\Delta^4$-cyclo-pentene-1 : 3-dicarboxylic acid.

P. C. GUHA *and* D. K. SANKARAN, Bangalore.

The addition of aliphatic diazo-compounds to conjugated double bonded systems has mostly been effected with hydrocarbons which, as a rule, accept diazomethane, etc., by a process of addition in 1 : 2 positions.

Dimethyl diazomethane reacts with ethyl muconate at $-18°C$ and yields ethyl isodehydroapocamphorate (b.p. 200°/100 mm.). Diazomethane reacts similarly with ethyl muconate to yield ethyl $\Delta^4$-cyclopentene- 1 : 3-dicarboxylate (I) which has resisted all attempts to reduce it into the saturated cyclopentane-1 : 3-dicarboxylic acid. The 1 : 4-addition, in this case, has been proved by the isolation of glutaric acid by successive stages of oxidation of compound (I).

110. Investigations on the nature of addition of aliphatic diazo-compounds to conjugated systems, Part II. Action of diazomethane and diazoacetic ester upon cyclopenta- and cyclohexadienes and their derivatives.

P. C. GUHA *and* G. D. HAZRA, Bangalore.

The present investigation has been undertaken with the object of synthesizing bicyclic compounds of the camphane and santane series by effecting 1 : 4-bridge formation in cyclic compounds, possessing conjugated double bonds, by the action of aliphatic diazo compounds. $\Delta^{1:3}$-dihydrobenzene and 2 : 3-dimethyl-$\Delta^{1:3}$-dihydrobenzene (cantharene) have not been found to react with diazomethane even after one month's standing at 0°. $\Delta^{1:3}$-dihydrobenzene reacts with diazoacetic ester to give a compound (b.p. 84°/2·5 mm.). That the addition has taken place in 1 : 2-positions (and not in 1 : 4), in spite of the starting compound possessing conjugated double bonds has been proved by reducing the product catalytically to ethyl norcarane carboxylate, b.p. 112–14°/19-20 mm. (the m.p. of the related acid is 97°C). The b.p. and m.p. of the corresponding ester and the acid as given by Ebel, Brunner and Mangelli (*Helv. Chem. Acta.*, 1929, *12*, 19–26) being 110-11°/18 mm. and 97° respectively, prove the identity of our product with theirs.

Cantharene reacts with diazoacetic ester to give an ester, b.p. 91–95°/2·5 mm., which gave two acids now under investigation.

To study the influence of negative groups like $CO_2Et$ and CO adjacent to 1 : 4-carbon atoms in conjugated double bonded systems, on the addition of diazomethane and diazo-acetic ester, etc., $\Delta^{1:3}$-dihydroterephthalic ester, *o*-benzoquinone and methylbenzoquinone are being condensed with these.

111. Synthesis of umbellulonic acid.

P. C. GUHA *and* M. S. MUTHANNA, Bangalore.

Ethyl isopropyl acrylate (Blaise and Luttinger, *Bull. Soc. Chem.*, 1905 (3), *33*, 648, 776) has been condensed with diazoacetone (*Annalen*, 1925, *1*, 34; 1916, *1*, 855) to yield a pyrazoline compound, b.p. 130–135°C 3 mm. (Found : N, 11·68%; calc. 12·39%). The pyrazoline compound splits off nitrogen at 180°C, and the resulting nitrogen free ester distils

at 135–145°/25 mm. and was expected to yield umbellylonic acid on hydrolysis. The resulting acid, however, does not readily crystallize but forms an oxime, m.p. 145-146°C (Found : N, 7·64% ; calc. 7-53%), and a semicarbazone, m.p. 170° (Found : N, 18·30% ; calc. 18·42%), the corresponding m.p.'s of the oxime of cisumbellulonic acid (derived from natural umbellulone) being 169-170°C ; semicarbazone not known.

The cis-configuration of umbellulonic acid now synthesised has been proved by its conversion into cis-umbellularic acid monohydrate. The latter does not depress the m.p. of an authentic specimen derived from natural sources.

## 112. Attempted synthesis of cantharidin, Part I.

P. C. GUHA *and* B. H. IYER, Bangalore.

The best condition under which the sodium derivative of oxalodiglycollic ester reacts with ethylene bromide (cf. *Sci. Cong. Proc.*, 1935, 146) is to heat the dry disodium derivative with an excess of the alkylene halide at 160–170° under reflux during 72 hours. When repeatedly crystallized from alcohol, the alkali insoluble portion of the product (structure advanced) melts at 174-75°C. The di-ester on hydrolysis with alkali readily gives the corresponding di-acid, m.p. 316°C (decomp.). The stability of the di-acid towards boiling hydrochloric acid (1 : 1) rules out the possible $\beta$-ketonic ester type of formula of the condensed product. Hence, the compound is represented by a formula in which three oxygen atoms take part in the formation of a bicyclo heterocyclic ring.

If the product had a $\beta$-ketonic structure, it would have been a very convenient starting material for the synthesis of cantharidin.

The sodium derivative of oxalodiglycollic ester has been similarly condensed with trimethylene bromide and the product melts at 139°. Oxalothiodiglycollic ester similarly reacts with ethylene bromide to yield an analogous alkali-insoluble product melting at 148–50°C.

## 113. Attempted synthesis of cantharidin, Part II.

P. C. GUHA *and* B. H. IYER, Bangalore.

The synthesis of cantharidin has been attempted starting from suitable furan derivatives, with a view to avoiding, in later stages, the necessity of constructing the oxygen bridge present in the cantharidin molecule.

The condensations of the di-acid chlorides of furan-2 : 5-dicarboxylic acid and tetra-hydrofuran dicarboxylic acid with zinc methyl iodide have been effected and the corresponding 2 : 5-diacetyl compounds have been isolated. It is intended to utilize these for the synthesis of cantharidin.

## 114. Researches on the formation of polycyclic compounds from succino-succinic ester.

P. C. GUHA, Bangalore.

Ethyl succinosuccinate has been condensed with brom-acetic ester and the resulting product yielded after hydrolysis and decarboxylation *cyclo*hexane-1 : 4-dione diacetic acid. The ester of this acid is being condensed with brom-acetic ester and phenyl brom-acetic ester (Reformatsky) with the object of converting the resultant tetra-esters into interesting tricyclic compounds.

The *bicyclo*-(2:2:2)-octane-derivative, m.p. 112°C (*cf.* last year's report), has been utilized for the preparation of interesting derivatives. It is intended to transform these into compounds of tricyclene type and other condensed systems.

## 115. The physical identity of enantiomers, Part V. The relation between concentration and viscosity of solutions of *d*-, *l*- and *dl*- forms of camphor, isonitrosocamphors, camphorquinone, camphoric acid and sodium camphorate.

B. K. Singh, Patna.

This paper deals with the problem of finding out a relation connecting concentration with the viscosity of solutions of *d*-, *l*- and *dl*- forms of camphor, isonitrosocamphors, camphorquinone, camphoric acid and sodium camphorate. The viscosity data of these compounds (*Proc. Ind. Acad. Sci.*, *5*, 484, 1937) have been analysed. The simple mixture law cannot express the viscosity of these solutions. Kandall's formula containing the cube root of the viscosity is also found to be unsatisfactory. The logarithmic viscosity formula of Arrhenius generally fits in well with observations, when the concentration is expressed as mols per 1,000 grams of solvent, the only exception being the isonitrosocamphors. The applicability of the Arrhenius equation is also illustrated by plotting logarithms of viscosity against molecular concentration when straight lines are obtained.

## 116. Synthesis of Thujane.

P. C. Guha *and* S. Krishnamurthy, Bangalore.

Ethyl 1-methyl-3-isopropyl-cyclopentane-2-one-1-carboxylate prepared from diethyl adipate (*Annalen*, 1906, *350*, 226) was reduced to the corresponding secondary alcohol which was then converted into ethyl 1-methyl-3-isopropyl-$\Delta^2$-cyclo-pentene-1-carboxylate by the action of phosphorus pentoxide in boiling benzene solution. This unsaturated ester reacted with diazomethane, on keeping for two weeks at 0°C to yield a bicyclic compound which can be regarded as thujane with a COOEt group in position 1. The corresponding acid obtained from the ester by hydrolysis (m.p. 93-94°) gave, on distillation with soda lime under reduced pressure, thujane b.p. 155-56°C; $n_D$, 1·4400; $d^{26}_{26}$ 0·8143; the corresponding values of thujane as given by Sommler and Feildstein being b.p. 156-57°C; $d^{22}_{21}$, 0·8158; $n_D$, 1·44121.

## 117. Attempts at synthesis of thujadicarboxylic acid.

P. C. Guha *and* M. S. Muthanna, Bangalore.

Ethyl $\beta$-isopropyl acrylate (*J.*, *77*, 942) has been condensed with sodio-malonic ester and the resulting product ethyl $\beta$-isopropyl-$\gamma'$-carbethoxy-$\alpha'$-glutarate (I), b.p. 145–148°/4 mm., isolated. The $\alpha$-bromo-compound (II), b.p. 175–176°/4 mm. (Found: Br, 20·82; calc. 21·0%), obtained from (I) by bromination, lost HBr on treatment with diethylaniline to yield an unsaturated compound (III) (structure advanced). The unsaturated ester on treatment with diazomethane yielded a product distilling at 135–140°/3 mm. and is expected to give thujadicarboxylic acid on hydrolysis and decarboxylation.

Work is also in progress on the synthesis of thujaketonic acid, starting from $\beta$-isopropyl-$\alpha$-acetoglutaric ester.

## 118. On synthesis of bicyclo- (1 : 2 : 2)-heptane and bicyclo-(2 : 2 : 2)-octane systems.

P. C. Guha *and* C. Krishnamurthy, Bangalore.

In continuation of the work reported last year (*Science Congress, Chemical Abst.*, 1937, 137), the synthesis of the bicyclo-(2 : 2 : 2)-octane compound, m.p. 112° has been attempted by double Dieckmann's condensation with hexane-1 : 2 : 5 : 6-tetra-carboxylic ester.

**Ethyl** hexane-(1 : 2 : 2 : 5 : 5 : 6)-hexacarboxylate obtained from ethyl butanetetracarboxylate and ethyl bromacetate, gives on hydrolysis and decarboxylation, hexane- 1 : 2 : 5 : 6-tetracarboxylic acid. The corresponding tetra-ester on treatment with sodium in toluene has given two products, one soluble (also giving coloration with ferric chloride) and the other insoluble in alkali. Methyl pentane-1 : 2 : 4 : 5-tetracarboxylate, prepared from methylene dimalonic and brom-acetic esters, has also been cyclized with sodium in toluene solution giving rise to two products—alkali-soluble and alkali-insoluble; the alkali-soluble products in either case on hydrolysis with boiling hydrochloric acid have given interesting compounds which are under investigation.

## 119. Synthesis of cyclohexane-spiro-cyclohexane derivative.

N. N. Chatterjee, Calcutta.

The effect of cyclohexane ring attached to a quaternary carbon atom in a chain on the formation of a new cyclohexane ring has been studied with the expectation of gaining some insight into the nature of strain in the existing cyclohexane ring.

The condensation product of cyclohexanone cyanohydrin and ethyl sodio-cyanoacetate when treated with ethyl $\gamma$-bromobutyrate gives diethyl 1-cyano cyclohexane-1-$\alpha$-cyanoadipate (b.p. 220–30°/3 mm.). This cyano ester on hydrolysis gives cyclohexane-1-carboxylic-1-$\alpha$-adipic acid (gummy solid). The corresponding ester (168–75°-4 mm.) is subjected to the action of sodium when cyclohexane-spiro-cyclohexane-2-one-3 : 6-dicarboxylate (b.p. 170°/3 mm.) is obtained. The ring formation takes place with almost equal facility as in the case of the corresponding cyclopentane ring (cf. *J. Indian Chem. Soc.*, *13*, 536, 1936).

## 120. Synthesis of polycyclic compounds having an angular methyl group.

N. N. Chatterjee, Calcutta.

The presence of an angular methyl group is encountered in the terpenes, alkaloids and sterol group but few synthetic methods exist for its introduction in a molecule.

Now with a view to synthesize polycyclic compounds having angular methyl group the investigation described below was undertaken.

Naphthyl magnesium bromide has been reacted with ethyl-2-methyl methyl cyclohexanone-2-carboxylate to yield ethyl-1-$\alpha$-naphthyl-2-methyl cyclohexanol-2-carboxylate (b.p. 220°–25°/6 mm.). This on dehydration yields ethyl-1-$\alpha$-naphthyl-2-methyl cyclohexane-2-carboxylate (b.p. 210–220°/6 mm.). This unsaturated ester is reduced catalytically to yield ethyl-1-$\alpha$-naphthyl-2-methyl cyclohexane-2-carboxylate (b.p. 208–10°/6 m.m.) 1-$\alpha$-naphthyl-2-methyl cyclohexane-2-carboxylic acid (b.p. 235–245°/7 mm.) obtained after hydrolysis of the ester is converted into acid chloride and subjected to the action of aluminium chloride to yield methyl hexahydro-peri-benzanthrone (b.p. 215–25°/4 m.m.) This derivative has been reduced to methyl hexahydro isochryso-fluoren, the constitution of which has been established by its conversion to isochryso-fluoren.

## 121. Superheated steam in the distillation of Atalantia monophylla oil.

M. T. Chobe *and* B. Sanjiva Rao, Bangalore.

The essential oils from Atalantia monophylla and spheranthus indicus have been distilled in steam at different temperatures and pressures and the data presented. The higher the temperature of the steam, the more is the quantity of oil distilling over per unit of steam. The properties of such oils distilled over have been examined. Atalantia monophylla oil was obtained in a yield of 0·4 to 0·5 per cent. from the leaves and was unaffected by distillation at 140°C. It has a pleasant citrus odour very similar to that of the oil from Zanthoxalum Bundrunga, Wall (*Jour. Ind. Inst. Sci.*, 1925, *8*, 174).

## 122. Essential oil from the leaves of *Sphrenthus indicus*.

(Miss) Mary Mathen *and* B. Sanjiva Rao, Bangalore.

The oil was obtained in a yield of 0·4 per cent. and has been found to consist of phellandrene and a mixture of mono and bicyclic tertiary alcohols. A crystalline acid and a crystalline alcohol $C_{15}H_{24}O$ (m.p. 64°) have been isolated from the oil.

## 123. Essential oil from *Litsœ zeylainca* : the occurrence of *dl*-cadinene.

(Miss) Mary Mathen *and* B. Sanjiva Rao, Bangalore.

A hydrocarbon $C_{15}H_{24}$ occurring in the essential oil from Litsæ zeylanica had been found to yield a solid dihydrochloride on treatment with hydrochloric acid but as sufficient quantity was not available it had not been closely investigated (*Jour. Indian Inst. Sci.*, 1932, *15*, 47). A fresh supply of two samples having become available, it was found that the dihydrochloride from one of them melted at 106°C after crystallization from ethyl acetate or acetone and was optically inactive. It appeared to be a hydrochloride of a hitherto unknown hydrocarbon which has been called litsenene. The hydrocarbon gave an excellent yield of cadalin on treatment with sulphur. The hydrochloride from the second sample of the oil was found to be a mixture from which the optically inactive dihydrochloride (m.p. 106°C) as well as the dihydrochloride of *d*-cadinene (m.p. 118°C; $\alpha_D$,-37·4) could be separated. It appears probable that litsenene is identical with *dl*-cadinene.

## 124. Synthesis in the cardiac aglucone series.

S. K. Ranganathan, Bangalore.

The cardiac aglucones would seem to owe their physiological action to the lactone group in the molecule, and the aetiocholane ring structure serves the purpose of a convenient framework for the placing of the lactone group. To substantiate this view-point, work has been started with the object of synthesizing lactones of related structure but carrying different rings. The method here adopted is based on the mechanism of formation of the lactones from norcholanic acid as postulated by Windaus (*Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen*, new-series, Vol. 1, No. 7).

Cyclo-pentyl bromide reacts with ethyl sodio-α-carbethoxy succinate to yield ethyl α-cyclopentyl-α-carbethoxy succinate, b.p. 172°C/6 mm. The corresponding tricarboxylic acid furnishes on thermal decomposition α-cyclopentyl succinic acid, m.p. 116-117°C (anhydride, b.p. 176°C/30 mm. ethyl α-cyclopentyl succinate, b.p. 147°C/9 mm.) and yields on reaction with sodium and ethyl formate what is apparently a mixture of the two α-

aldehydic cyclopentyl succinic acids. Ethyl α-cyclopentyl-β-aldehydo succinate has been isolated via its copper salt. (*p*-nitrobenzoyl ester, m.p. 238°).

Experiments undertaken in connection with the synthesis of α-cyclopentyl-succinic acid by a different method are also described, as also the condensation of cyclopentyl bromide with ethyl sodioacetone-dicarboxylate with a view to the ultimate synthesis of Wieland and Dane's acid $C_{18}H_{20}O_6$ (*Z. Physiol. Chem.*, 1933, *216*, 91).

## 125. Preparation of pure thevetin from the seeds of *Thevetia neriifolia.*

J. K. Lahiri *and* R. N. Chopra, Calcutta.

The glucoside thevetin is likely to prove to be a potent drug useful in cardiac trouble as shown by recent clinical trials. For the isolation and purification of the glucoside, the published methods either lack in detail or lead to very poor yields. Details of a modified method for the isolation and purification of thevetin are given. Some of its properties and reactions together with a complete bibliography are also added. The pharmacological action of the compound was found to be similar to that described by Chen and Chen. Further work on its pharmacology is in progress.

## 126. Investigation on the constitution of 'Artostenone', a keto compound related to sterols, present in the Indian summer fruit 'Artocarpus Integrifolla', Part V. Oxidation of artostenone.

M. C. Nath, Dacca.

In continuation of my work of 'Investigations on the constitution of "Artostenone"' (*Proc. Ind. Sci. Congr.*, 1937; Hoppe-Scyler's *Z. Physiol. Chem.*, *247*, 9, 1937) experiments have been extended to study the action of different oxidizing agents on artostenone.

1. Oxidation of artostenone has been carried out by means of both neutral and acid permanganate.
2. A di-keto acid (di-keto artostanic acid) of the formula $C_{30}H_{50}O_4$, m.p. 136°C, has been obtained in both the processes.
3. The molecular weight of this di-keto acid as determined by cryoscopic method with benzene as solvent is 452; the formula requires 474 as the molecular weight.
4. This acid gives a dioxime, m.p. 173°C, and an anilide, m.p. 140-141°C.
5. Nitric acid oxidation results in the formation of a nitro acid with two condensed rings, which dissolves in potassium hydroxide solution with orange-red colour.
6. The nitro acid melts at 157–159°C with decomposition and its molecular weight has been found to be 229.
7. Oxidation with chromium trioxide gives a substance (a keto acid ?) melting at 88-90°C.

## 127. Investigation of the constitution of 'Artostenone', Part VI. Tautomerism of the double bond in artostenone and its relative position with respect to the keto-group.

M. C. Nath, Dacca.

1. Artostenone on refluxing with alcoholic solution of sulphuric acid (5%) is converted into the isomeric compound α-artostenone.
2. α-artostenone melts at 99-100°, and its oxime has m.p. 193-194°.

3. Artostenone does not condense with benzaldehyde, whereas α-artostenone forms benzylidene derivative.
4. It has been found that di-hydro artostenone also forms condensation product with benzaldehyde.
5. The number of bromine atoms, which enter a molecule of di-hydro artostenone, by substitution, is three, while it is two in the case of the unsaturated compound, artostenone.
6. It is suggested that the CO group is at $C_{12}$ whilst the double bond is between $C_9$ and $C_{11}$.

## 128. Chemical and pharmacological examination of the roots of *Hemideamus indicus*, Part I.

A. T. DUTT, S. GHOSH, *and* R. N. CHOPRA, Calcutta.

The roots are used in the Indian indigenous system of medicine and are said to act as diuretic, diaphoretic and tonic. The plant is known as the Indian Sarsaparilla. The roots, collected locally, were found to contain an essential oil, corresponding to about 0·225 per cent. of the air dried material, of which about 80 per cent. consisted of a solid crystalline compound melting at 42·4°C. This was identified as 2-oxy-4-methoxy-benzaldehyde. The aroma of the drug, originally ascribed to coumarin, is due to this aldehyde. Two sterols, designated as Hemidosterol and Hemidesmol have also been isolated and analyzed. They melt at 176° and 161°C and show specific rotations of +69·87°C and +57·0°C respectively. Besides the presence of resins, tannins, etc., the roots show the presence of a glucoside, further work on which is in progress.

## 129. Chemical examination of mango ' chep ' (*Mangifera indica*).

S. K. VASISTHA *and* SALIMUZZAMAN SIDDIQUI, Delhi.

The fresh mango ' chep ' in liquid condition as well as the semi-solid mango chep resin have been investigated. The odorescent principle, present in the fresh chep, could not be isolated by steam distillation, which appears to destroy it. From the dry mango chep a resin (mangiferen) $C_{21}H_{34}O$, a resinous acid (mangiferic acid) $C_{40}H_{60}O_4$, and a resinol (mangiferol) $C_{42}H_{72}O_4$, were isolated and studied. Contrary to expectations, these resinous principles were found to be not allied to bhilawanol or anacardic acid. The degradation and oxidation products of mangiferen, which was more fully investigated, largely brought out their close relationship to the abietic acid series of resins, and supported the more recent view of resins being condensation products of isoprene.

## 130. The biogenesis of the terpenes and camphors.

K. GANAPATHI, Bangalore.

Taking the clue from the relative abundance and the occurrence side by side of the various constituents of the oils, a theory of the biogenesis of the terpenes and camphors has been advanced starting from linalool. The chemical and biochemical aspects have been discussed and the suggested schemes have been shown to accommodate satisfactorily most of the known facts.

## 131. Sesquiterpene ketones, their structure and synthesis.

J. L. SIMONSEN, Bangor.

## 132. Chemical examination of the root of *Tabernamontana coronaria.*

P. PARAMESWAREN PILLAY, Trivandrum.

By percolation with cold alcohol, followed by removal of the solvent under reduced pressure, 7·7% of extractive matter were obtained. From these, 1·65% of total alkaloids were isolated, which could be separated into white and yellow amorphous bases which are very easily oxidized by atmospheric oxygen. There was also present in the extract a crystalline sterol, a sterol glucoside, palmitic, oleic and linoleic acid and an amorphous neutral substance.

## 133. Jute-seeds—*Corchorus capsularis*, Part IV. A resinous bitter from jute-seeds.

N. K. SEN, Dacca.

A resinous bitter has been isolated from the mother-liquor of Corchorin, the crystalline active principle of jute-seeds (*Corchorus capsularis*). It resembles the compound isolated from the seeds by E. Merck for Kobert for his experiments on animals. When hydrolyzed it yields reducing sugar and an insoluble aglycone. The paper deals with the structure of this compound provisionally named Corcho-resin.

## 134. Synthesis of new local anæsthetics.

K. N. GAIND *and* J. N. RAY, Lahore.

Various $\beta$-acyloxy $\beta$-phenyl ethyl amines have been synthesized with a view to find an ideal local anæsthetic. Solutions of hydrochlorides of $\beta$-*p*-aminobenzoyloxy $\beta$-phenyl ethyl methylamine (and related substances) are stable to boiling and are sterilizable. These substances diffuse slowly and hence can be used without adrenaline to produce anæsthesia lasting for a fairly long time.

## 135. A new colorimetric test for novocaine and primary amines.

S. N. CHAKRAVARTI *and* M. B. ROY, Agra.

When primary amines are treated with a solution of paradimethylaminobenzaldehyde in presence of hydrochloric acid, a yellow, greenish yellow or orange colouration is immediately obtained. This reaction can be utilized as an excellent test for primary amines and novocaine. This test should prove to be particularly valuable where a large number of samples have to be tested for the presence of novocaine, an usual adulterant for cocaine, as this test is not given by the majority of the other usual adulterants of cocaine and by cocaine itself.

## 136. Synthesis of arsenic analogue of succinimide.

H. N. DAS GUPTA, Calcutta.

It has been found possible to condense succinyl chloride with phenyl dichloro arsine to produce *l*-phenyl cyclo succinarsine. The structure assigned to the ring compound was proved to be correct by reducing the same by sodium and alcohol to a known arsine like phenyl cyclo tetramethylene arsine (Grutner and Krause, *Ber.*, 1916, *49*, 437). The m.p. and mixed m.p. of the methiodide derivative was found to be identical with that from 1 : 5-dibromobutane.

## 137. Benzo-isoquinolines.

B. B. Dey *and* S. Rajagopalan, Madras.

Isoquinolines with a naphthalene nucleus are not numerous and attempts have now been made to synthesize these bodies by different routes and lay down general rules regarding their formation. It is interesting to note that all attempts to cyclise the acylated α-naphthyl methyl amines on the peri-position were unsuccessful. This experience recalls the difficulty of preparation of isoquinolines from amines of the benzylamine type previously recorded by one of the authors.

## 138. Syntheses of *l*-chloromethyl- and *l*-α-chloroethyl-isoquinolines and their derivatives.

B. B. Dey *and* T. R. Govindachari, Madras.

These have been prepared from homo-piperonyl amine and chloracetic anhydride and lactide respectively. The corresponding cyano-methyl isoquinolines are found to condense with aldehydes to give interesting styrene derivatives. *l*-cyanomethyl-6, 7, methylenedioxy-3, 4, dihydro-isoquinoline undergoes a rather curious oxidation with hydrogen peroxide to the corresponding *l*-keto-tetrahydroisoquinoline.

## 139. Synthetical experiments in the paraberine group, Part II. A synthesis of 3 : 12-dimethoxy-6 : 15 : 16 : 17-tetrahydro-17-keto-paraberine.

S. N. Chakravarti *and* P. L. N. Rao, Agra.

To throw light on the preferential selection of angular structures by nature, attempts were made to synthesize compounds of the type of paraberine having linear structures. Attempts to synthesize tetrahydro-paraberine from (i) dibenzyl-methylamine by the action of formaldehyde or through formyl derivative and from (ii) *dl*-N-benzyl-phenylalanine were unsuccessful. These results support the conclusions of Perkin and co-workers on the subject. Attempts were next made to synthesize suitable dimethoxy-tetrahydro-paraberines as it was thought that these would be more amenable to synthesis owing to the presence of para-activating methoxy groups. With this object attempts were first made to synthesize 3 : 3′-dimethoxy-dibenzyl-methylamine by three different routes. In first of these methods, *m*-methoxybenzaldehyde was reduced to the corresponding alcohol 3-3′-dimethoxy-hydrobenzoin, m.p. 110°C, being formed as a bye-product during reduction—and the alcohol converted into the bromide by the action of hydrogen bromide. The bromide was then converted into the cyanide which could be smoothly hydrolyzed by methyl alcoholic potash to 3-methoxyphenyl acetic acid. 3 : 3′-dimethoxy-dibenzyl-ketone was prepared by means of the Grignard reaction from the above bromide and cyanide and also by the distillation of the thorium salt of 3-methoxyphenyl acetic acid. The ketone was converted into the oxime and then reduced electrolytically when only a small amount of a basic substance was formed. In another method 3 : 3′-dimethoxy-dibenzyl malonic acid, m.p. 185-186°C was first synthesized and then converted into 3 : 3′-dimethoxy-dibenzyl acetic acid m.p. 102°C, from which the corresponding amide was prepared. The amide did not give the desired amine in good yields when Hofmann's reaction was tried. This is being further investigated.

3 : 12-dimethoxy-6 : 15 : 16 : 17-tetrahydro-ketoparaberine was synthesized in the following manner :—

*m*-methoxy-benzaldehyde and hippuric acid were condensed together and the azlactone hydrolyzed with ·2% sodium hydroxide solution to β-3-methoxyphenyl-α-benzoylamino-acrylic acid, m.p. 170°C, in an yield of

over 90%. The latter acid was reduced to β-3-methoxy-phenyl- α-benzoyl-aminopropionic acid, m.p. 144°C, which was hydrolyzed to 3-methoxy-phenylalanine, m.p. 215°C, in quantitative yields. The formyl derivative of 3-methoxy-phenylalanine was converted into N-formyl-3′-methoxybenzyl-3-methoxy-phenylalanine, m.p. 186–188°C, by the action of 3-methoxy-benzyl-chloride. The formyl compound was hydrolyzed to N-3′-methoxybenzyl-3-methoxy-phenylalanine, m.p. 228°C, which was converted into N-3′-methoxy-benzyl-6-methoxy-1 : 2 : 3 : 4-tetrahydroisoquinoline carboxylic acid, m.p. 233–235°C, by the action of formaldehyde. This acid, which was also synthesized from 6-methoxy-1 : 2 : 3 : 4-tetrahydroisoquinoline-3-carboxylic acid, m.p. 263-264°C, on cyclization with 70% sulphuric acid gave the keto paraberine only in about 15% yield. The more difficult formation of the dimethoxy-keto-paraberine compared to the ease of formation of the dimethoxy tetrahydroprotoberberines lends indirect support to the conclusions of Perkin and co-workers.

## 140. Chaksine.

K. S. NARANG *and* J. N. RAY, Lahore.

Siddiqui and Ahmed (*Proc. Ind. Acad. Sci.*, 1935, *5*, 421) isolated the iodide of an alkaloid from Cassia Absus. Various degradation products of this alkaloid have been isolated and their structure discussed.

## 141. Synthesis of meta-oxazine compounds.

N. W. HIRWE *and* (MISS) K. D. GAVANKAR, Bombay.

5-nitrosalicylamide resisted all attempts at condensation with chloral under usual conditions, but a product was obtained under pressure. The compound is a meta-oxazine derivative.

It gave an acetyl derivative. On hydrolysis with alkali it decomposed to 5-nitro salicylamide, chloroform and methyl-amine. On hydrolysis with strong aqueous ammonia, the ring is opened and 2-hydroxy-5-nitro-trichloro amino ethyl benzamide was obtained. By the action of nitrous acid it was converted into 2-hydroxy-5-nitro-trichloro hydroxy ethyl benzamide, which is a normal condensation product of chloral with 5-nitro-salicylamide not obtained directly. It can be reconverted into the above meta-oxazine compound by acetic anhydride in alkaline solution.

## 142. Synthesis in the alloxazine, isoalloxazine and lumazine groups.

K. GANAPATHI, Bangalore.

In connection with the work on the chemotherapy of tuberculosis, the synthesis of a series of compounds of the above groups have been undertaken.

4 : 5-diaminouracil sulphate (I) condenses with phenylglyoxal hydrate to give 6- or 7-phenyllumazine, which gives the dimethyl derivative, m.p. 275°C, with diazomethane. While benzil condenses with (I) to give 6 : 7-diphenyllumazine, many disubstituted benzils were found to give only traces of the condensation products. Piperil gives 6 : 7-di (3 : 4-methylenedioxyphenyl) lumazine in poor yield. Phenylglyoxal aldoxime and also the mono-oximes of benzil, piperil and phenanthrenequinone failed to condense with 4-amino uracil.

Camphorquinone condenses with (I) to yield 2′ : 3′-camphorolumazine.

## 143. A study of acridine derivatives.

S. J. DAS GUPTA *and* U. BASU, Calcutta.

2-chloro-7-methoxy acridine containing a dialkylamino alkylamine side chain in position 5, has been generally found to possess an antimalarial property. With a view to study the influence of other chain or group on this acridine ring, certain acridyl amino antipyrines have already been prepared (Das Gupta and Basu, *Science and Culture*, 1937, *2*, 585); and now 2-amino-4-phynyl thiazole has been condensed with 2, 5-dichloro-7-methoxy and 2, 5, 9-trichloro-acridines to give 2-(2′-chloro-7′-methoxy-acridyl) and 2-(2′, 7′-dichloroacridyl) amino-4-phenylthiazoles, m.p. 246-47° and 269-70° respectively. They readily form monohydrochlorides of molecular weight 454 and 458·5. Similarly, 4-methyl-5-hydroxy ethyl thiazole is being fused with the above acridino derivative. As the molecular weights of the resulting condensation products lie within the limit required for an antimalarial drug (cf. Slotta and Behnisch, *Ber.* 1935, *68*, 754) it is expected that the product would be of value.

## 144. Acridine derivatives. Part I.

K. S. NARANG *and* J. N. RAY, Lahore.

2-methoxy-7-nitro-9-chloro acridine (the numbering followed is that of the American Chemical Society), m.p. 223°C, has been condensed with *p*-toluidine (m.p. 212°C), *p*-phenetidine (m.p. 182°C), *p*-amino acetanilide (m.p. 287°C), *n*-butylamine (m.p. 106°C) and similar other aromatic, aliphatic and heterocyclic amines. The corresponding products in each case have been further reduced to the related amines by anhydrous stannous chloride in glacial acetic acid. The 7-amino derivatives have in some cases been acylated.

These substances crystallize with a large number of the solvent molecules. In some cases, the substances had to be dried at 150–200°C in high vacuum before a correct analytical value could be obtained.

By analogy with prontosil, *p*-aminobenzene sulphonamide has been condensed with the parent substance and the product reduced to the corresponding amine and its antiseptic action against hæmolytic steptococci *in vivo* and *in vitro* is being studied.

## 145. Studies in the Naphthol AS series. Part II. Fastness to rubbing.

R. B. FORSTER, S. R. RAMACHANDRAN, *and* K. VANKATARAMAN, Bombay.

While the presence of the -CO-NH- group in N-AS leads to increased substantivity in comparison with β-naphthol, the various members of the series differ widely among themselves in respect of their substantivity. The precise degree of substantivity is largely a function of the colloidal state of the naphthol solution, which would in turn be presumably a function of the constitution, although there is no definable relation between constitution and the known order of substantivity. The common view that fastness to rubbing runs parallel to the substantivity of the naphthol lacked experimental verification, not only with regard to the absence of any quantitative relationship between substantivity and rubbing fastness, but (what is more important from the practical point of view) also in the sense that an unsubstantive naphthol may lead ultimately to dyeings of excellent fastness to rubbing. Provided the other stages of the dyeing process were carried out under the optimum conditions, the vital factor was the after-treatment.

In addition to the nitrogen assay method described in Part I, a more rapid qualitative procedure for the examination of rubbing fastness is outlined.

## 146. Condensation and coupling of methone (5 : 5-dimethyl-dihydroresorcinol) with some aromatic diamines and their tetrazonium salts respectively.

B. H. IYER, Bangalore.

Chakravarti *et al* (*J. Indian Inst. Sci.*, 1931, *14A*, 141) and Iyer and Chakravarti (*J. Indian Inst. Sci.*, 1931, *14A*, 157 ; 1934, *17A*, 41) have studied the behaviour of methone towards a few aromatic aldehydes and diazonium salts of aromatic mono-amines. From these data it has been deduced that methone behaves generally in a mono-keto-mono-enol form. The azo-dyes obtained from the mono-amines have been found to be fugitive to cotton but substantive to wool and silk.

Methone has now been coupled with the tetrazonium salts of benzidine, 9-toluidine and *o*-dianisidine. The coloured substances thus obtained are being tested for their dyeing properties.

Methone has also been condensed with the above mentioned diamines and the products described (*cf.* Haas, *J.*, 1906, *89*, 187 and 387).

## 147. The action of diazo salts on cutch.

S. R. RAMACHANDRAN *and* K. VENKATARAMAN, Bombay.

Perhaps the most important of the natural colouring matters which have survived is cutch or catechu, which is cheap and available in large quantities in this country. The ordinary methods of applying cutch to cotton, wool and silk in dyeing and printing are well established, but the use of catechu is restricted to 'catechu brown' or 'cutch brown' on cotton and to weighting purposes in silk dyeing. The processes now described relate to the productions of a larger variety of shades than the usual browns without impairing the admittedly excellent fastness properties of cutch dyeings. Many of the natural colouring matters of the flavone, flavanol and pyran groups contain the phloroglucin nucleus and are therefore capable of coupling with diazo salts. Cutch dyeings have now been treated with an extensive series of diazo salts leading to a range of bright and attractive shades ; another advance in the utilization of cutch is the development of padding processes in which the oxidation of catechin which hinders coupling with diazo salts is obviated. Two of the factors that influence the shade obtained from a given diazo salt are the *p*H of the developing bath and the quality of the cutch in regard to the relative contents of catechin and catechutannic acid.

A process not involving after-chroming is to use chromium acetate, alone or in admixture with sodium acetate, in the cutch-padding liquor in the diazo solution. The shades are characterized by their brightness. Some of the browns would be difficult to match by the indigoid or anthraquinone vat colours.

Cutch may be employed in conjunction with diazo salts in several styles of calico printing. The range of colourings from cutch and diazo salts in printing is naturally much more limited than in the case of the arylides of hydroxynaphthoic acid, but this limitation is a favourable factor in so far as a quiet and harmonious colour scheme is automatically accomplished.

## 148. Studies in indigoid dyes. Part II.

S. K. GUHA, Patna.

The indigoid dyes described in this paper obtained by the condensation of 6-methyl-3-hydroxythionaphthene (Friedlander, *9*, 589 ; Auwers

and Thies, *Ber.*, 1920, *53*, 2293) and aliphatic and aromatic aldehydes respectively have been compared with those of the corresponding 5-methyl derivatives (Guha, *J. Indian Chem. Soc.*, 1935, *12*, 659). It has been found that Martinet's rule (*Rev. Gen. Mat. Col.*, 1921, *25*, 17) is applicable to this series of compounds when one methyl group is present in the thionaphthene nucleus of the molecule (cf. Acenaphthenequinone and Isatin Series, Guha, *J. Indian Chem. Soc.*, 1933, *10*, 679 ; 1936, *13*, 94 ; Guha and Basu-Mullick, *ibid.*, 1934, *11*, 395 ; Guha, *ibid.*, 1937, *14*, 240 ; F.P. 693903 of 14-4-1930, *Chem. Zentr.*, 1931, *102*-I, 2944 ; A.P. 1850758 of 10-12-1930 ; *Chem. Zentr.*, 1932, *103*-II, 1374).

2 : 3-naphthoxythiophene (Friedlander and Woroshzow, *Annalen*, 1912, *388*, 18) and 3-chloro-, 3-bromo-, β-methoxy-acenaphthene-quinone respectively produced red-violet vat dyes. (Cf. Schwz. P.P. 107133–35 of 29-3-23 ; *Chem. Zentr.*, 1925, *96*-II, 860 ; Dutt, *Ber.*, 1934, *67*, 1326). The halogenated products imparted uniform red-violet shades on cotton from alkaline hydrosulphite vat whereas the methoxy compound produced only light violet shade (cf. 2-thionaphthene-8′-(1′-methoxy, acenaphthylene-indigo, its 5-methyl and 6-methyl derivatives, Staudinger, Goldstein and Schlenker, *Helv. Chim. Acta*, 1921, *4*, 342 ; Guha, *loc. cit.*).

## 149. Dyes derived from thiohydantoin. Part III.

G. P. Pendse, Gwalior.

Thiohydantoin possesses a reactive methylene group situated between two negative groups. Due to this reactive methylene group thiohydantoin has been previously condensed with a number of nitroso and iso-nitroso compounds, resulting in products possessing interesting dyeing properties. (Pendse and Dutt, *J. Ind. Chem. Soc.*, 1930, *7*, 953). In Part II of this series a number of aromatic aldehydes have been condensed with thiohydantoin which resulted in both acetylated and deacetylated condensation products. (Namjoshi and Dutt, *J. Indian Chem. Soc.*, 1931, *8*, 241).

To complete this series of condensations with thiohydantoin, various aliphatic and aromatic ketones have been subjected to condensation using acetic anhydride as condensing agent. Where there are more than one keto groups, it is found that generally one molecule of the ketone condenses with one molecule of thiohydantoin. A few acid anhydrides have also been condensed with thiohydantoin in presence of sulphuric acid, as the condensing agent. The condensation products have interesting dyeing properties.

## 150. 9.10-phenanthrathiophene-2-thionaphthene-indigo.

P. C. Dutta, Muzaffarpur.

In this paper 9-phenanthrathiofuran-1.2-dione has been condensed with 3-hydroxythionaphthene and the corresponding indigoid dye obtained. The condensation was brought about by HCl in acetic acid solution of the constituents in an atmosphere of carbon dioxide. Similar other dyes are being investigated.

## 151. 9-thiolphenanthrene and some of its derivatives.

P. C. Dutta, Muzaffarpur.

Except 3-thiolphenanthrene prepared by Field (*J.* 1915, 1214) the other thiolphenanthrenes are not known. So it was deemed interesting to prepare thiolphenanthrenes especially the 9-compound, which was expected to give some thio-indigoid dyes which might be of interest from the author's view point of the relation between colour and chemical constitution.

Werner and his collaborators have shown that by the action of concentrated sulphuric acid on phenanthrone three sulphonic acids—2, 3, and 9 are produced simultaneously. Fieser (*J. Amer. Chem. Soc.*, 1929, 2460) later on has introduced a method by which these sulphonic acids can be obtained in better yields and also in a more pure condition. In the present paper the preparation of 9-thiolphenanthrene and some of its derivatives—phenanthrene-9-disulphide and 9-phenanthrathiofuran-1.2-dione—have been described.

## 152. Azine dyes derived from 9-phenanthrathiofuran-1.2-dione.

P. C. Dutta, Muzaffarpur.

9-phenanthrathiofuran-1.2-dione prepared from 9-thiol-phenanthrene has been condensed with various ortho-diamines such as *o*-phenylene diamine, 2-chloro-4.5-toluene diamine, 2.3-diaminoquinoxalin, and 2.3-diaminophenazine to get the corresponding azines. As has already been observed, the colour of these azine dyes deepens as the number of azine rings in the molecule increases.

## 153. Chemical examination of the fixed oil from the seeds of *Croton Sparsiflorus*, Morung.

K. A. N. Rao *and* S. Aravamudhachari, Annamalainagar.

The seeds of this shrub which grows extensively in South Arcot District of Madras Presidency, give on extraction with $CCl_4$, a thick, brownish yellow oil with an unpleasant taste and odour. The oil which forms 21·4% of the seeds by weight, rapidly polymerizes on exposure to air.

The physical and chemical constants which have been determined are as follows: —

Specific gravity at 31°C : 0·9626; Refractive Index at 31°C : 1·4775 ; Saponification value: 195·4 ; Acid value: 10·1 ; Iodine value (Wijs): 164·5; Reichert-Meissl value: 1·43; Polonske: 1·03 ; Unsaponifiable matter: 2·6% ; Solid acids : 6·5% and Liquid acids : 80·0%.

The oil is being examined with a view to identify its constituents.

## 154. Acidity in butter and ghee.

B. N. Banerjee *and* N. S. Doctor, Bangalore.

Lately the acidity in butter has been tried to be reduced as low as possible in a number of ways. Depending on the temperature and nature of souring, the acidity may vary from 4° to 15° in acid value. During churning, melting or evaporation a fair quantity of acidity passes into ghee and this materially affects the quality, especially Vitamin A, carotin bodies, and flavour of ghee. An acid value from 0°·3 to 2°·0 is the limit that can be permitted in a sample. A high acid value is very harmful in that it acts as a pro-oxidant and very quickly brings about loss of vitamins and flavour especially when butter or ghee is heated in cooking operations. Neutralization of acidity of cream, washing of butter, and electro-dialysis may be performed to reduce the acidity in butter or ghee and thus improve the quality of the same.

## 155. Use of tintometer in the detection of adulteration of butter-fat (Ghee) by agar-plate method.

K. Venkata Giri *and* P. N. Bhargava, Bangalore.

A new colorimetric method for the detection of adulteration of ghee has been described. With the help of a Lovibond Tintometer standard colour units for pure ghee and other oils have been fixed. The usefulness and the application of the method have been indicated.

## 156. Aroma in butter.

(MISS) R. KARNAD, Bangalore.

During recent years, more and more attention is being directed to the aroma-producing micro-organisms of butter since these play an important part in the natural flavour and aroma development in butter. The identification and estimation of the flavouring substance of butter is very essential as the market value of butter depends chiefly on its flavour.

The typical butter flavour is due, in part, to the products of fermentation in which milk sugar takes a part during the process of souring of milk. It may also come from the decomposition products of the proteins. The chemical changes are largely to be traced to the action of enzymes produced by bacteria.

There is considerable evidence to show that the aroma of butter made from ripened cream is chiefly due to small amounts of diacetyl.

Various species of lactic acid bacteria were isolated from curds by plating on whey-agar medium. There was variation in the aroma and flavour produced in milk by different acid-forming types. A new aroma-producing bactorium was isolated which gives a particularly fine butter aroma and gives a positive test for diacetyl.

Aroma and flavour development in the milk culture is best at 25–28°C. in 48 hours. A certain amount of acid must be present before the maximum flavour is developed. It is particularly interesting to note the favourable influence of yeast extract in improving the flavour. There is a marked increase in the production of diacetyl on the addition of 10 per cent. yeast extract. The flavour is also improved by the addition of small quantities (0·2 per cent.) of citrates. The volatile acidity is not increased by the addition of citric acid or citrates to the milk before inoculating the culture.

From the results obtained it can be concluded that the flavour and aroma are mostly due to diacetyl in the culture and not due to free volatile acids.

The fact that the aroma of the butter culture can be considerably improved by the addition of citrates and yeast extract seems to open up new possibilities in the field of cream ripening for butter-making.

## 157. Chemical examination of *India aloes, aloe vera, aloe indica*, Royle.

N. N. GHOSH *and* R. N. CHOPRA, Calcutta.

The common aloe found in Bengal and known as aloe vera does not contain any aloin, the active principle of aloes. It was found to contain very small quantities of an essential oil, a fixed oil, resin, gums, emodin, some anthraquinone derivatives and chrysophanic acid. The aloe emodin, which also has some purgative properties, is present in too small a quantity to be effective in a dose of 1 or 2 tolas of the juice or pulp. If aloe is to be administered as a hepatic stimulant and purgative, species other than the one ordinarily found in Bengal should be selected, since it was found that the total extract as well as other fractions supposed to contain the active principle failed to produce the therapeutic action of aloes.

## 158. Chemical examination of the roots of *Paris polyphylla*, Part I.

A. T. DUTT, N. R. CHATTERJEE, S. GHOSH, *and* R. N. CHOPRA, Calcutta.

The roots were collected from Nepal and the investigation was undertaken to find out if this Indian species contained any active glucosides found in the allied species, P. quadrifolia, analyzed in Europe. The present investigation showed the presence of about 8 per cent. of cane

sugar and two glucosides, one crystalline and the other amorphous. The glucosides resembled Paridin and Paristyphuin found in P. quadrifolis and the amorphous glucoside has been found to possess strong physiological action. Further work on the glucosides is in progress.

### 159. The chemical and pharmacological examination of the young shoots of *Bambusa arundinacea.*

N. N. Ghosh, S. Ghosh, *and* R. N. Chopra, Calcutta.

The young shoots are used in the Indian indigenous system of medicine for their various therapeutic properties. The shoots examined were found to contain about 0·03 per cent. of HCN and about 0·23 per cent. of free benzoic acid. The juice pressed out from the shoots was found to contain 0·027 per cent. of HCN and 0·16 per cent. of free benzoic acid. The full grown green leaves of the bamboo were found to be free from HCN or benzoic acid. Aqueous solutions of the alcoholic extracts of the young shoots did not show any action against microfilaria and they did not show any emmenogogue properties. Some of the therapeutic properties ascribed to it can be explained by the presence of free HCN and benzoic acid. The other toxic principle besides HCN, as surmised by Moorthy and Stewart in their recent study, has been proved to be the free benzoic acid, the concentration being sufficient to explain the antiseptic and larvæcidal properties ascribed to it.

### 160. Chemical and pharmacological examination of the leaves of *Erythroxylon monogvnum*, Roxb.

N. N. Ghosh *and* R. N. Chopra, Calcutta.

The leaves are reported to have refrigerent properties and at one time it was eaten during famine for its property of allaying the pangs of hunger. The leaves were collected from the Madras Presidency and the work was undertaken to study the nature and properties of the alkaloids as well as to find out if it contains any workable quantity of cocaine or similar alkaloids. The present investigation showed that the important constituents are an essential oil and about 0·1 per cent. of alkaloids. Both acid and alkaline hydrolysis of the alkaloids gave cinnamic acid. The alkaloids produced no mydriasis or anæsthesia. A cinnamyl cocaine has got no therapeutic value and the conversion into the pharmacopœial cocaine will not prove to be an economic proposition unless the content of alkaloids can be improved by cultivation.

### 161. Fluorometric determination of the acid and saponification values of lac.

N. N. Murty *and* H. K. Sen, Ranchi.

The determination of the acid and saponification values of lac and its constituents is of great importance in a study of its constitution. Thymol blue has been used as an indicator in general, but in the case of dark-coloured lacs such as Burma Kusum and saponified solutions of the ether-soluble resin, this indicator fails to give a sharp end-point, and in such cases, potentiometric methods have to be employed, but the operation takes a longer time and the electrodes are susceptible to poisoning.

The orange-yellow colour of an alcoholic solution of lac changes very gradually to pink, starting at a low *p*H. Lac solutions exhibit an orange-red fluorescence when exposed to ultra-violet radiation from a mercury arc. This fluorescent colour of lac solutions changes from orange-red to green, rather sharply, near about the end-point when titrated with alkali. The possibility of using this change in the fluorescent colour for the fixing of the end point of dark-coloured lac solutions has been investigated. It was found that the method works well with comparatively less dark solu-

tions, but in the case of very dark solutions, the addition of $\beta$-naphthol as a fluorescent indicator while titrating with alkali proved very successful.

## 162. Contribution to the study of the bleaching of lac, Part I. The action of the chlorine-bleach on the resin constituents of lac.

N. N. MURTY, Ranchi.

A study of the chemical changes undergone by the resin constituents of lac during bleaching with hypochlorite solution has been made.

Bleaching is accompanied by an increase in the acid value and an apparent increase in the saponification value and ester value of lac. On making due allowance for the reaction between the chlorine present in bleached lac and the alcoholic potash used in saponification, real saponification and ester values can be calculated. The real saponification value of shellac is about 5 per cent. higher than that of unbleached lac, thus indicating an increase in the carboxyl groups due to oxidative changes brought about by the chlorine bleach. Aleuritic acid, a constituent of lac, does not appear to be affected by the chlorine-bleach. The hydroxyl number generally decreases slightly on bleaching.

Chlorine enters into the resin molecules, and its content increases steadily as the lac is progressively bleached, while the iodine value decreases rapidly in the beginning, and then tends to attain a minimum value. The chlorine in bleached lac exists only partly as an addition compound, the excess entering the molecule through substitution.

The chemical changes, viz. oxidation and chlorination, are brought about in the resin molecules almost immediately on the addition of the bleaching agent, but the changes in the colouring matter, although proceeding simultaneously, take some time to attain completion. The rate of absorption of bleach is quicker in poor bleaching lacs than in good Kusum lac, and is further enhanced by employing a higher temperature and lower *p*H.

When bleached lac is allowed to remain in the alkaline solution, after all the hypochlorite added has been consumed, the following changes take place, the extent of these changes depending upon the duration, temperature and *p*H :

(*a*) The chlorine content decreases, the unsaturation increases due to splitting off of HCl and the colour of the bleached lac tends to return.

(*b*) The acid value increases due to hydrolysis, consequently the ester value decreases.

(*c*) The saponification value appears to decrease slightly due probably to the splitting off of carbon dioxide from the carboxyl groups or due to removal of some acid constituent of lower molecular weight during washing.

A slower rate of attack on the resin molecules by a gradual addition of the bleaching liquor gives a product which is less prone to become insoluble than a rapidly bleached product. Higher alkalinity of the bleaching liquor and other conditions which bring about hydrolysis give a bleached lac which will have a longer life, but which will have the disadvantages of high acid value and poor colour.

## 163. Contribution to the study of the bleaching of lac, Part II. Factors which influence the keeping quality of bleached lac.

M. N. MURTY, Ranchi.

1. The life under heat of bleached lac gives an indication of its keeping quality only in the case of extremely bad or good samples.

2. Heat and/or acid treatment of lac shortens the life of the bleached lac obtained therefrom.
3. Too rapid an addition of the bleaching liquor, or addition in one lot, is not conducive to the long life of bleached lac. After such treatment, however, the life of the bleached lac can be improved at the sacrifice of light colour by allowing it to remain in the alkaline solution for a considerable time and then carrying out the precipitation.
4. Higher concentrations of soda used in dissolving the lac act favourably on the keeping quality of bleached lac, but unfavourably on its colour.
5. The use of acetic acid for precipitation, at least towards the end of neutralization, helps in prolonging the life of bleached lac.
6. Precipitating of the slightly basic side improves the keeping quality of bleached lac.
7. Washing bleached lac precipitate with hot (especially boiling) water leads to poor keeping quality and deterioration in the colour of bleached lac.
8. Storing bleached lac in a cool place (below 10°C.) preserves both colour and solubility.
9. The higher the chlorine content in bleached lac, the faster does esterification take place in the varnish prepared out of that lac.

## 164. Considerations on the chemical constitution of shellac based on unsaturation.

M. VENUGOPALAN *and* H. K. SEN, Ranchi.

The separation of shellac into two distinct fractions by the treatment of solvents leaves no doubt as to the mechanical nature of the product known as shellac. It is curious, however, that the proportion of hard resin to soft resin is practically constant in almost all the samples of shellac so far examined. The variation in this ratio is so negligible that one would be tempted to postulate some chemical combination between hard and soft resins. As far as the present knowledge goes, the assumption of auxilliary valencies is all that can be put forward, but basing an analogy with lignocellulose, the adsorption or paltization of hard resin in the comparatively fluid medium of soft resin does not appear unlikely. Molecular weight determinations based on the lowering of the m.p. of camphor indicate that the mutual presence of hard and soft resins is only mechanical. Artificially prepared mixtures of soft and hard lac resins in the proportion of 30 : 70 respectively have given the same lowering of the m.p. of camphor as by an equal quantity of shellac. The molecular weights of the hard resin complex and that of the soft resin are such that the calculated value of the molecular weight of shellac and the experimentally found value agree very well. The agreement persists also if an indirect method of determining the molecular weight by the implications of any group or groups existing in shellac is taken into consideration. Thus if the iodine value of shellac is taken to be 14 and if in the whole complex the existence of one double bond is promised, then the weight of the complex is 1814. Similarly, the weight of the complex of hard resin is about 2,000 on the evidence of 13 being its iodine value. The iodine value of soft resin is approximately 18, from which a molecular weight of the complex is calculated to be 1,410, but the molecular weight determination gives the value of 460 only, showing thereby that the soft lac resin itself is probably a mixture of three component portions mechanically mixed, only one of which is the unsaturated member. The total picture, therefore, of a shellac complex is this : the hard lac portion of a molecular weight of about 2,000 admixed with soft lac resin composed of at least three molecular species the sum of the molecular weights of which is about 1410. The very important work of Gardner and his collaborators on the separation of shellac into different fractions by solvents lends additional support to this view.

Whilst the constituent acids in the soft resin are being examined, some progress as to the conception of the chemical structure of hard lac resin has been made from the proportion of aleuritic acid available from it. Aleuritic acid (trihydroxy palmitic acid) does not exist as such in this complex, but as externally or internally condensed esters and ethers. So far, aleuritic acid to the extent of 30% of hard lac has been isolated by the hydrolysis of the latter. If we assume, that at least one molecule of aleuritic acid has entered into condensation with some other unknown complex by the elimination of 1 mol. of water, the molecular weight of hard lac should be $\frac{304-18}{28} \times 100$ or 1029 which is half of that obtained by the melting point depression method. To reconcile this, one has to assume that the molecule of hard lac resin is composed of two aleuritic acid molecules, the undetermined complex having a molecular weight of 7432. It has to be assumed also that the unsaturation in the hard resin is located somewhere in this undetermined portion. with this distinction, however, from its position in the soft resin that it forms part of a whole complex, and not that it exists in a member separate from the total complex.

The nature of the linkage between aleuritic acid and the undetermined complex has not yet been definitely established beyond the fact that the carboxyl group of aleuritic acid esterifies a hydroxy group of the undetermined complex. But there is reason to believe that some of the (OH) groups in aleuritic acid are held in ether linkage with the undetermined complex. The main ground for this supposition has been the isolation by Venugopalan and Sen and Thakur, Bhowmik and Sen of auto-condensation products of aleuritic acid where, besides esterification, other linkages had to be postulated to account for free acid and saponification values—a conjecture which was further proved by the determination of acetyl values in these auto-condensation products.

## 165. Studies on the constitution of shellac, Part II. Condensation of aleuritic acid.

A. T. Thakur, T. P. Bhowmick, *and* H. K. Sen, Ranchi.

The auto-condensation of aleuritic acid in presence of dry HCl has been studied with the result that complexes with four to nine molecules of the acid in ester linkage have been isolated. The higher members are solid, melting and softing below 80°C. It is expected that by allowing the condensation to proceed further, resins of higher melting points could be produced.

Similar auto-condensation products by the simple heating of aleuritic acid (Venugopalan and Sen) have been isolated which have certain improved physical and chemical properties.

The authors perceive in these auto-condensations, the mechanism of the biological production of lac on the host trees through the catalysis of enzymes.

## 166. On aleuritic acid.

P. C. Mitter *and* P. C. Dutta, Calcutta.

The formula $CH_2OH(CH_2)_5CHOHCHOH(CH_2)_7COOH$ has been ascribed to aleuritic acid, an important constituent of shellac from analytical data. The object of this work is to verify this constitution by actual synthesis.

$\omega$-phenoxy-pentamethylene bromide was condensed with ethyl sodioacetoacetate giving ethyl-$\omega$-phenoxy-2-acetyl-$n$-heptylate (B.P. 180°C/3 mm.). The sodium derivative of this substance was condensed with the chloride of the half-ester of sebacic acid giving ethyl-$\omega$-phenoxy-11-acetyl-11-carbethoxy-10-keto palmitate which on hydrolysis gives $\omega$-

phenoxy-10-keto palmitic acid, m.p. 90°C (semicarbazone m.p. 136°-137°C). It is proposed to convert the ketonic acid into $\omega$-phenoxy-$\Delta^{9:10}$ hexadecenoic acid by the method of Robinson and Robinson (*J.C.S.*, 1925, *127*, 175). On dephenoxylation and treatment with potassium permanganate or perbenzoic acid it is expected to give aleuritic acid.

## 167. Recovery of insoluble lac as ester-gum.

A. K. THAKUR, T. P. BHOWMICK, *and* H. K. SEN, Ranchi.

Due to accumulation of shellac at the consuming end, a certain amount of accumulation of stick lac is bound to happen at the producing end. The element of speculation further plays important part in determining the period of storage of stick lac. There is deterioration on storage. The utilization of lac thus damaged or rendered insoluble is, therefore, a most important problem.

The ordinary methods of reconditioning of damaged lac do not appear to have so much prospect from the commercial point of view, as the direct conversion of such lacs into a technically usable product. The paint and varnish industry appears to be a more possible channel for the consumption of damaged lac than any specialized industry, where the quality of shellac is a determining factor of its use. Accordingly a sample of damaged insoluble lac was first acetylated by heating for 3 hours in an excess of acetic anhydride at the boiling temperature of the reagent. The resulting acetylated product was either freed from the excess of acetic anhydride and then further treated with glycerin, or in the boiling solution glycerin was added in requisite quantity and the recovery of acetic anhydride effected by distillation. The residue obtained was a viscid liquid having a free acid value—as low as 7. This product is completely soluble in alcohol, ether and other industrial solvents. On boiling in linseed oil in presence of a drier like cobalt linoleate at 200°C. for 1 hour, it makes a varnish of good drying quality and film hardness. Its use as a plasticizer is being investigated.

## 168. Extraction of waste lac by alcohol.

M. RANGASWAMI *and* H. K. SEN, Ranchi.

Further experiments on the extraction of waste lac with a view to determine, under laboratory conditions, the rates of filtration, recovery of solvent, quality of lac obtained, etc. have been undertaken with the result that under suitable conditions, the extraction of Kiri has been found to be a profitable industrial process. The erection of a pilot-plant is under consideration. A preliminary fermentation of waste lac or treatment with a saturated sodium chloride solution renders the subsequent filtration easier.

## 169. Development of transparent and water-resistant shellac varnish.

M. RANGASWAMI, Ranchi.

Previous studies on wax-free shellac varnish films indicated that the removal of wax from shellac resulted in a film which, though transparent and somewhat water-resistant, lacked the flexibility and adhesion of original shellac film. Some plasticisers like tricresyl phosphate were found to overcome this defect in a large measure but the films obtained from so plasticised shellac were found to be more affected by water as a result of plasticising. The defect, however, was overcome by the introduction of urea, thio-urea or sulphur monochloride in the plasticised products. Thus weather-resistant varnishes have been developed having suitable adhesion and flexibility.

## 170. The use of *p*-tolyliodochloride for determining the unsaturation of shellac.

M. VENUGOPALAN, H. K. SEN, *and* S. C. DEY, Ranchi.

*P*-tolyliodochloride being a more active halogenating agent than iodine monochloride, the possibility of using an acetic acid solution of this reagent in place of Wij's solution for determining iodine values has been studied in great detail and it has been found that quite reliable figures could be obtained for unsaturated fats and oils and for shellac and rosin, if this method is adopted under specified conditions. Tolyliodochloride being a more reactive substituting reagent than iodine monochloride, somewhat higher figures for iodine absorption with the former reagent are usually obtained on account of some substitution besides the addition of the double-bond taking place and a correction has to be applied for arriving at the absorption figure due to addition only. It has also been found that a mixture of 90 parts of tolyliodochloride reagent with 10 parts of a solution of iodine in acetic acid results in a more reactive reagent than the solution of tolyliodochloride alone and iodine absorption values could be obtained in 15 minutes as compared with 1 hour required with Wij's solution and 18 hours in the case of Hubl method.

## 171. Mycobiology of jute-stacking.

CHITTARANJAN BARAT *and* G. C. DAS GUPTA, Calcutta.

The jute yarns of commerce are not homogeneous, and it is the common practice, in order to make it approximately so, to cut out the bottom ends of the same, and after proper dressing and moistening, stack them in heaps, when some biochemical changes take place, the temperature of the stack goes high and remains so for several days, and when the yarn ends become softened and loosened to the desired extent, they are taken out and worked. A marked acidity, part of which is steam-volatile, also develops in the meantime. The period of stacking depends upon the humidity and temperature of the atmosphere to a great extent and therefore varies according to the season. The whole process is generally controlled by experience.

Bacteriological examination of the softened specimens reveals the presence of a group of symbiotic bacteria presumably of the nature of cellulose fermenting organisms described by Sen and Das Gupta (*J. Indian Chem. Soc.*, 1934, *11*, 853), as well as a mould, supposed to be *Aspergillus Fumigatus* (Fres), previously discovered by Finlow (*Memoirs of the Deptt. of Agriculture in India*, 1918, *5*, 36). The isolation of these various organisms and their action on pure cellulose as well as jute fibres are being studied with a view to adequately control the above process of jute-stacking.

## 172. A comparison of the properties of lignin as obtained from (1) the market, (2) from jute-fibre, and (3) from rice straw.

S. S. GUHA SIRCAR *and* J. M. SEN, Dacca.

In Part I of the investigation it is shown that all the three lignins (obtained by a modification of Willstätter method) contain methoxyl, hydroxyl and methylenedioxy groups, but in different proportions. They can be methylated and acetylated by the usual reagents. It is shown that jute-lignin presumably is formed by the polymerization of 4 units of a molecule like coniferyl alcohol or aldehyde and have a molecular weight of about 780, whereas rice-straw lignin apparently contains less methoxyl than is needed on such an assumption regarding its constitution. Commercial lignin seems to be somewhat differently constituted.

In Part II the degradation of jute-lignin according to Freudenberg's method (1937) is described and similar products, viz. veratric, veratroyl formic and iso-hemipinic acids are isolated. Under other conditions proto-catechuic acid and catechol are found. These observations support an aromatic constitution.

In Part III phenol-lignin obtained from jute is described. It is analysed for C, H, and methoxyl and from an analysis of its Ba salt a molecular weight of about 1010 is indicated.

Further work is in progress.

## 173. The detection and estimation of degradation in cotton, Part II. The distinction between oxycellulose and hydrocellulose.

R. B. FORSTER, S. M. KAJI, *and* K. VENKATARAMAN, Bombay.

Tests for distinguishing between acidic or hydrolytic degradation and oxidative degradation of cellulose have been submitted to fresh scrutiny. The basis of the known tests is the carboxyl content of oxycellulose and its consequent affinity for metals. All, including a new variation in which copper retained by oxycellulose is detected by means of rubeanic acid, were only applicable to oxycelluloses of copper number higher than 0·5 prepared under alkaline conditions. Scholl (1911) showed that degraded cotton in presence of caustic soda was capable of reducing indanthrene yellow to the blue vat; taking advantage of the solubilisation of oxycellulose by caustic soda solution, the reaction could be utilized for distinguishing between oxycellulose and hydrocellulose and was applicable to every type of oxycellulose. An interesting feature of the combined action of vat dyes and boiling alkali on cotton was that even celluloses with very small copper number (0·1—0·2) were dyed pale shades without the addition of hydrosulphite. The copper number was not increased thereby, the aldehyde group of the terminal glucose unit apparently functioning in the active form.

With regard to coupling power with diazo salts, hydrocellulose resembled normal cellulose rather than oxycellulose and this made available a new method of distinction. From this point of view the possibility that in oxycelluloses of the type which coupled readily with diazo salts a secondary alcoholic group to the aldehydic or carboxylic group has been oxidised to the carbonyl must be considered.

## 174. Recent work on alcoholic fermentation. (A discourse).

SIR ARTHUR HARDEN, London.

## 175. Mechanism of acetic acid fermentation.

K. P. BASU *and* MD. ABDUL QUADER, Dacca.

The action of 18 dyestuffs on the oxidation of ethyl alcohol and acetaldehyde by *B. Orleanese* and *B. Acetic* have been studied.

It is shown that the dyestuffs which have powerful toxic action are basic in character. The acid dyestuffs cause relatively small or no inhibition.

The dyestuffs have a more powerful toxic action on the oxidation of aldehyde than of alcohol, thus showing that one enzyme oxidises alcohol to aldehyde while another oxidises aldehyde to acetic acid, i.e. two separate enzymes are involved in the two stages of oxidation of ethyl alcohol to acetic acid.

## 176. A micro-organism from rotten potatoes.

H. K. Sen *and* G. C. Das Gupta, Ranchi.

A new type of facultative anaerobic bacillus has been isolated from rotten potatoes, the optimum temperature and hydrogen ion concentration for reaction being 42°–43°C. and 8 respectively. It can ferment starch, all pentose and hexose sugars as also glycerin very readily. The products obtained by such fermentation can be grouped under two heads.

(1) Liquid products consisting of alcohol, formic, acetic, lactic and succinic acids, acetone in small quantities and still smaller quantities of acetyl methyl carbinol.

(2) Gaseous products consisting mainly of carbon dioxide and hydrogen.

The bacillus seems to belong to the same genus as Bacterium aceto-ethylicum and Macerans, but is definitely a different species. The main difference in its cultural characteristics from the other two are the following :—

(*a*) It is non-motile, whereas the other two are motile.

(*b*) It ferments galactose and laevulose both under anaerobic and aerobic conditions with either peptone or ammonium salts as the source of nitrogen. Bacillus Macerans cannot ferment galactose and laevulose at all.

(*c*) It differs also in the quantity, if not entirely in quality, of fermentation products, producing non-volatile acids such as lactic and succinic acids forming about 20–28% of the total sugar. Smaller quantities of acetone and acetyl methyl carbinol are also amongst the products of fermentation. The organism is found as rods $2-4 \times 1\mu$ occurring singly, (no chains), non-motile, having spores to one side measuring $1{\cdot}5-2 \times 1\mu$ gram positive.

## 177. Studies on the enzymes of the seeds of *Butea frondosa*, Part I. Proteolytic enzymes.

N. R. Chatterjee, S. Ghosh, *and* R. N. Chopra, Calcutta.

The seeds are said to possess definite anthelmintic action, specially against ascaris. The report that a proteolytic enzyme present in Ficus laurifolia is the anthelmintic principle of the juice led the authors to look for enzymes in Butea seeds. The present investigation has shown that the seeds contain a proteolytic enzyme which appears to be ereptic in nature. It hydrolyses peptones and casein but does not act on egg albumin or on fibrin. It liquefies gelatin. It acts best in a slightly alkaline medium but whether this is significant enough to explain the action on worms in the intestine cannot be asserted. The optimum temperature seems to be near about 40°C. Hydrocyanic acid is found to have a definite activating influence on this enzyme.

## 178. Studies on the enzymes of the seeds of *Butea frondosa*, Part II. Lipolytic enzyme.

N. R. Chatterjee, S. Ghosh, *and* R. N. Chopra, Calcutta.

The seeds were found to contain a lipolytic enzyme in addition to the proteolytic enzyme reported earlier. Its action has been studied on substrates like olive oil, castor oil and rape seed oil and it acts on all of these equally well. The lipase seems to act best on a slightly alkaline side and shows an optimum temperature of about 40°C. The aqueous extracts of the raw seeds as well as the defatted seeds act equally well.

## 179. Isolation of $\beta$-3 : 4-dihydroxyphenylalanine from the seeds of *Mucuna pruriens.*

MANAYATH DAMODARAN *and* RAGHAVIAH RAMASWAMY, Madras.

$\beta$-3 : 4-dihydroxyphenylalanine, an amino acid of great physiological interest on account of its relationship on the one hand to adrenaline and on the other to the animal pigments known as melanins, has been isolated from the seeds of Mucuna pruriens in yields amounting to 1·5% of the raw material.

Two new crystalline derivatives suitable for the identification of the amino-acid have been prepared, viz. the hydantoin and the picrolonate.

The behaviour of the substance towards reagents usually used in the determination of other biologically important substances with analogous reducing properties has been investigated. It is shown that dihydroxyphenylalanine does not interfere in the usual methods for determining ascorbic acid but is likely to do so in the estimation of thiol compounds by reactions involving the use of phospho-18-tungstic acid.

It is shown that the substance is stable under the usual conditions of acidic hydrolysis of proteins, so that, if present in proteins, it should be possible to isolate it from such hydrolysates.

## 180. Proteins of Indian vegetables, Part I. Drumstick.

Y. V. SREENIVASA RAU *and* V. RANGANATHAN, Bangalore.

Drumstick contains 17 per cent. protein calculated on the total nitrogen basis. Prolamine and globulin have been isolated according to standard methods and the total yield of these does not account for even 50% of the total nitrogen. This suggests that it may be due to (1) the presence of proteolastic enzymes, or (2) high percentage of non-protein nitrogen. These points are under investigation.

The prolamines and globulins have been analyzed according to the Van Slyke's procedure. The prolamin is characterized by a very low content of amide N and a high basic N, while ordinarily the prolamines are characterized by a high amide nitrogen content (about 20 to 22% expressed in terms of total N) and a low basic nitrogen content (about 5 to 8% of total N).

## 181. Biochemical investigation of some species of Bengal fish. Extraction and chemical analysis of the proteins from Ruhee (*Lobeo Rohita*) and Hilsa (*Clupea Ilisa*).

K. P. BASU *and* H. N. DE, Dacca.

The percentage of total nitrogen extractable by different solvents is 96·4 in the case of Ruhee and 93·0 in the case of Hilsa.

In both the cases the maximum amount of protein is extracted with 2% salt solution.

From Ruhee, water extract—32·4%, salt extract 5·2%, 75% alcohol —3·2% and 0·2% alkali 55·6% of total nitrogen are obtained ; the corresponding values for Hilsa are 26·8%, 9·9%, 3·2% and 53·7% respectively.

The nitrogen distribution of Ruhee and Hilsa Globulin and glutelin has been determined by the method of Van Slyke as modified by Plimmer and Rosedale.

Tyrosine and tryptophane contents of the proteins have been determined by the colorimetric method of Folin *et al.* Tryptophane contents of both Hilsa and Ruhee proteins are equal. Ruhee glutelin contain more tyrosine than the Hilsa glutelin.

Ruhee fish proteins contain more sulphur containing amino acids than the Hilsa fish proteins.

Addition of *l*-cystine to a Hilsa diet at 5% level causes growth, which in its absence is incapable of promoting any growth.

## 182. Action of dyestuffs, potassium cyanide and octyl alcohol on the metabolism of amino-acids in liver and kidney tissues and with liver extract.

K. P. BASU *and* MD. ABDUL QUADER, Dacca.

Both in the case of *d*-amino acid deaminase and *l*-amino acid deaminase basic dyestuffs act as poison while acidic dyestuffs are practically without any effect. Hence the active group in the dehydrogenase is acidic in nature. Probably the active group in all dehydrogenases is acidic in nature.

*l*-amino acid deaminase and *d*-amino acid deaminase are two distinct enzymes. KCN and octyl alcohol inhibit the oxidation of *l*-amino acids only, thus confirming the results of Krebs.

## 183. De-amidising action of proteolytic enzymes, Part I. Experiments on natural proteins.

MANAYATH DAMODARAN *and* V. P. ANANTHANARAYANAN, Madras.

The isolation of asparagine (Damodaran, 1932) and of glutamine (Damodaran *et al.* 1932) from enzymic digests of proteins has given direct demonstration of the existence of amido groups in the protein molecule. But before any conclusions of a quantitative nature can be drawn as to the origin of the ammonia which is an invariable product of protein hydrolysis, it is necessary to have more exact information on the deamidising activity of the proteolytic enzymes than is at present available. Such information was in the first place necessary to enable a proper choice of enzymes and conditions of experiment to be made so that hydrolysis of protein could be effected with the least amount of decomposition of the ammonia yielding complexes. Secondly it was hoped that a comparative study of the liberation of ammonia from proteins and from synthetic substrates might provide analogies from which the nature of the precursors of ammonia in the former might be inferred.

In the present paper the results of quantitative experiments on the action of pepsin, trypsin, erepsin and papain on three typical proteins, viz. casein, edestin and gliadin are described. It is shown that the three animal proteases exert no appreciable deamidising action during digestion of proteins, the ammonia formed being unconnected with enzyme action and having its origin most probably in secondary decompositions of protein cleavage products in the acidic or alkaline media employed. Papain on the other hand has either a definite deamidising action or contains a constituent which has such action.

## 184. De-amidising action of proteolytic enzymes, Part II. Experiments on synthetic substrates.

MANAYATH DAMODARAN *and* E. K. NARAYANAN, Madras.

The formation of ammonia by the action of pepsin, trypsin, erepsin and papain on the following substrates were studied: glycine-amide, leucine amide, asparagine, glycyl asparagine, chloracetyl asparagine, *d*-leucyl-asparagine, *dl*-leucyl-asparagine, anhydro-glycyl-asparagine.

Purified erepsin was found to act on the amide groups of glycine-amide, leucine-amide, asparagine and chloracetyl-asparagine though much more slowly than on the peptide bonds in dipeptides. It would appear from this that the specificity relations of peptidases are not so strict as much recent work especially of the Willstätter school has tended

to show, being more of a quantitative than a qualitative nature. In keeping with this view is the fact that the peptide bond in chloracetyl-asparagine is split by erepsin contrary to accepted views on the mode of action of this enzyme. Papain showed a slight but definite de-amidising action on glycine-amide and leucine-amide.

## 185. The non-protein nitrogen (N.P.N.) of milks.

KAMALA BHAGVAT, Bangalore.

The N.P.N. from cow's and ass's milks have been prepared and subjected to Van Slyke's analysis. The results do not show any striking differences in composition of the two N.P.N. fractions.

An independent estimation of tyrosine, arginine and urea has been carried out.

Attention has been drawn to the three types of role which the N.P.N. will possibly play in the nutrition of animals.

## 186. On crystallization of the globulins from P. aconitifolius Jacq.

KAMALA BHAGVAT, Bangalore.

Crystalline globulins have been prepared from aconite bean by the methods of dilution and $Am_2SO_4$ saturation. The three preparations thus obtained were tested for purity and their tyrosine and tryptophane contents determined. The different preparations show some difference in their total nitrogen and tyrosine contents.

## 187. I. The chemical composition (Van Slyke) of the proteins and the biological values (according to balance sheet method) of *Fenugreek*, *Lathyrus sativus*, *Sorghum vulgare* and *Eleucine coracana*. II. Phosphorus in vegetable proteins.

Y. V. SREENIVASA RAU, Bangalore.

It was reported in the *Proceedings of the Indian Academy of Sciences*, Vol. I, No. 2, August, 1934, that the globulins from Lathyrus sativus prepared by different methods contained varying amounts of phosphorus. Further fractionation of the globulin has shown that the phosphorus in the globulin is present only as an impurity and not in organic combination.

## 188. Solubilizing action exerted by proteoclastases on the proteins of pulses.

V. RANGANATHAN *and* B. N. SASTRI, Bangalore.

In the course of a study of the digestibility of the pulse proteins in their natural environment, it was found that pepsin exerted a remarkable solubilizing (and hydrolytic) action on the proteins, while trypsin did not exert any marked influence. The extent of action exerted on different pulses is different and appears to bear a relation to the digestibility of the proteins. This observation explains the need for treating the proteins first with pepsin and subsequently with trypsin in the *in vitro* procedure for studying the digestibility of proteins.

## 189. Glycero- and pyrophosphatase systems of plant and animal tissues.

K. VENKATA GIRI, Bangalore.

The phosphatase activities of several plant materials were measured. In oil seeds the enzyme concentration is much greater than in seeds rich in proteins and starch. The ratio of the activities of pyro- and glycerophosphatases present in a large number of seeds varies widely from one plant to another. This ratio is found to be always higher than one in the case of plant materials, and less than one for the system existing in animal tissues. The experimental findings lead to the conclusion that the two phosphatases are non-identical.

## 190. The chemical composition and the enzymic content of Indian honey.

K. VENKATA GIRI, Bangalore.

The analysis of a large number of samples of pure Indian honey have been made for the purpose of purity determinations in order to set standards by which the purity of honey could readily be ascertained. The analytical figures for sucrose, glucose, lævulose, ash, moisture, acidity, diastatic number and phosphatase activity for pure samples have been determined. It has been found that there exists a correlation between the fermentation and diastatic number and phosphatase activity. The evaluation of honey and its susceptibility to fermentation on the basis of its phosphatase content is discussed.

## 191. Studies in the nutritive value of Indian foodstuffs. I. Enzymic digestibility of Bengal gram (*Cicer arietinum* Linn).

V. RANGANATHAN *and* B. N. SASTRI, Bangalore.

Previous work on the digestibility of the proteins, is largely confined to the isolated proteins. The present study relates to the study of the nature and extent of the digestion accompanying the treatment of the whole meal by peptic followed by the tryptic and ereptic enzymes. The amount of non-basic nitrogen fraction in the peptic digests is low (14·6%) while the basic fraction is remarkably high (83·3%). The corresponding figures for the tryptic digests are 47·3 and 47·6 respectively. The arginine content of the peptic digests is 49·6% while that of the tryptic digests is 20·6%. The complexity of the digests as determined by the ratio total nitrogen : amino nitrogen is about 7 : 1 in the case of peptic digests while the factor for tryptic digests lies between 1 and 2 : 1.

## 192. The state of ascorbic acid in plant tissues.

B. C. GUHA, J. C. PAL, *and* P. N. SEN-GUPTA, Calcutta.

Evidence is provided in favour of the view that part of the indophenol reducing substance (ascorbic acid ?) in cabbage is present in a combined form, from which the reducing substance is released by heating. Alcoholic and ethereal extracts of cabbage also show this behaviour. There is a difference in the reducing value obtained after cold and hot treatments of cabbage suspensions and extracts with hydrogen sulphide. Further, chloroform extracts of cabbage, which do not reduce the indophenol indicator, do so after heating and the reducing substance thus produced disappears in large part on treatment with ascorbic acid oxidase.

## 193. Effect of vitamin C, glutathione and cysteine on the growth of certain micro-organisms.

B. C. GUHA *and* G. C. DAS GUPTA, Calcutta.

It has been found that vitamin C, glutathione and cysteine in very small concentrations have a marked stimulating effect on the growth of the fungi—*Aspergillus niger*, *A. Oryzæ*, *A. flavus*, *Saccharomyces cerevisiæ* and *S. ellipsoideus* in a synthetic medium. On the other hand, there seemed to be an inhibiting effect on the growth of bacteria like *B. coli*, *B. subtilis* and *Aerobacter aerogenes*. The problem is being further investigated.

## 194. Relation between vitamin C and plant phosphatases.

K. VENKATA GIRI, Bangalore.

The effect of vitamin C either alone or in presence of various other substances on the enzymic splitting of phosphorus compounds has been studied with the purified enzyme from sprouted soya beans. It has been found that the oxidation of vitamin C by metallic catalysts like copper and other oxidising agents brings about the inhibition of the activity of phosphatase. The inhibition by vitamin C—Cu complex is entirely annulled by the presence of glutathione, cysteine, cystine, $H_2S$ and other reducing agents, KCN and sodium hydrosulphite. The hydrolysis of pyro-phosphate by the enzyme is less affected by vitamin-Cu complex than that of glycerophosphate hydrolysis. This difference in the behaviour of pyrophosphate hydrolysis has been found to be due to its stabilizing action on the vitamin against catalystic oxidation. Dehydroascorbic acid either alone or in presence of cupric salt has been found to have no influence on the activity of the phosphatase. Enzymic oxidation of vitamin C does not influence the activity of the phosphatase.

Evidence is given to show that the inhibiting action of vitamin C is due to the presence of traces of Cu in water and in the reagents used for the experiments and that the antiparalysing action of thiol and disulphide compounds is due to the protection of the vitamin against oxidation by metal catalysts. The opposite actions of vitamin C and glutathione and other compounds suggest a possible means by which the action of phosphatase may be controlled in plant life.

## 195. Vitamin content of mangoes.

B. N. BANERJEE *and* G. B. RAMASARMA, Bangalore.

The vitamin A and C content of mangoes is interesting in many ways. In addition to the nutritive value, an assay of the vitamin content enables us to judge the quality of the numerous varieties that are grown in India. The effect of grafting, pollination, climate, soil, manurès and weather conditions, humidity and rainfall has been investigated. The vitamin content is very variable, and depends to a certain extent on the variety, time of plucking, and stage of ripening. A few varieties are very rich in vitamins A and C. Some are very rich in vitamin C only and are well suited for preservation in the form of pickle, the vitamin value being richer than lemons or oranges. Sour and fibrous types of mangoes are not fit for table use but can be used for pulp drying.

## 196. The preparation and properties of polysaccharides from vibrio choleræ and related organisms.

R. W. LINTON, D. L. SHRIVASTAVA, *and* S. P. MOOKERJI, Calcutta.

The important discovery of Heidelberger and Avery (1923) that carbohydrates are responsible for the type specificity and virulence of pneu-

mococci, stimulated a considerable amount of research into the polysaccharides of many other bacteria. Linton and his co-workers have been making an intensive study of the immunochemistry of the vibrios during the last five years. Recently specific polysaccharides have been prepared by growing vibrios in suitable media for 72 hours at 37°C. and then working with the filtrate of such cultures, which contain the active polysaccharide. During the whole course of preparation the use of alkalis, mineral acids and other similar drastic means of purification have been scrupulously avoided. The type of medium used has been found to have a profound effect on the quality and the quantity of the polysaccharide isolated.

The polysaccharide preparations thus obtained are free from proteins, phosphates, glycogen and starch. They give strong Molisch tests but do not reduce Benedict's solution until hydrolyzed. They have great serological activity and even when diluted over 10 million times still give strong reactions with the homologous antisera. They contain nitrogen and are highly acetylated. The importance of these two points is discussed in the paper. The probable importance of a lipoid constituent has also been mentioned.

These new preparations have given rise to many interesting and important lines of work, which are being followed up.

### 197. Effect of *p*H, temperature and chemicals on the activity of the proteolytic enzymes in snake venoms.

B. N. Ghosh *and* M. L. Kundu, Calcutta.

The hydrolysis of proteins and peptones by a number of snake venoms has been studied under various conditions. It is observed that the *p*H at which the proteolytic enzymes in snake venoms exhibit their optimum activity, depends to a certain extent on the nature of the substrate used. Thus, with gelatin and egg albumin as substrates, their optimum activity is at *p*H 8·2 while with casein as substrate their optimum activity is at *p*H 7·0 or *p*H 7·2. The activity of the proteolytic enzymes is inhibited by the addition of chemicals like KCN, $HgCl_2$, $H_2S$ to the substrate solution. The maximum hydrolysis of the proteins takes place in the neighbourhood of 50°C. It appears from these experiments that the proteolytic enzymes present in the snake venoms studied are either identical with or very similar to trypsin.

## Industrial Chemistry

### 198. Mechanism of hydrogenation in a continuous process.

S. K. K. Jatkar *and* V. T. Athavale, Bangalore.

In continuation of the previous work, the kinetics of hydrogenation in a continuous process were studied by taking into account considerations based upon mass law. The velocity co-efficient at any temperature generally rises with an increase in rate, but in the case of some of the catalysts, the rise could be accounted for by the adsorption factors.

A study of the rate of change of velocity with temperature shows that there are four temperatures at which the velocity abnormally changed with a change either in the catalyst or in the oil. These temperatures are 125°C, 150°C, 175°C and 200°C respectively.

The effect of a change in the composition of the oil was studied by hydrogenating cotton seed, groundnut and olive oils. It was noted that whatever be the catalyst or the oil the velocity at 150°C is considerably high in all the cases, while at other temperatures it rises or falls depending on the catalyst and the oil used.

For cotton seed oil, though the initial velocity coefficient-temperature curve is quite smooth, an analysis of the oil shows that velocity of hydro-

genation of linolein gives a maximum at 125°C, a minimum at 150°C and then increasing values up to 200°C. The olein on the other hand shows a minimum at 125°C and a maximum at 150°C and comparatively high value at 180°C. Analysis shows that linolein hydrogenates straight to stearin at 200°C.

Consideration of the apparent heats of activation for different temperatures has brought forth the following results : (1) The major portion of the activity of a catalyst is due to the presence of two active centres of nickel, each having a temperature of maximum reaction. These temperatures are 135°C and 175°C respectively. Out of these two, the centre having a maximum at 135°C has got a specific affinity for linolein while the other has got a specific affinity for olein, (ii) olein (independent of the active centres) reacts faster at 150°C than at other temperatures, (iii) superimposed on this is the activity due to activation of hydrogen. The activation of hydrogen is at its maximum at 110° while at 200° the solution of hydrogen is probably the only factor present.

Hydrogenation of a single substance like ethyl oleate showed two maxima at 150°C and 175°C respectively in the velocity coefficient-temperature curve, and confirmed the conclusions given in (i) and (ii) in the last paragraph.

## 199. Use of arsenious oxide as an opacifying agent in lead glasses and the manufacture of China glass in India.

ATMA RAM *and* LAL C. VERMAN, Calcutta.

Arsenious oxide, when added to glass batch to the extent of about 4% produces dense white opacity in high lead glasses. For the development of a proper degree of opacity, the molten glass should be allowed to cool very slowly from 700°C. If the resulting glass is suddenly cooled, very little opacity is developed. This opaque glass has been used as a decorative enamel for glass bangles. Cyrolite does not appear to be the proper opacifying agent for preparing such enamels. Addition of 0·1% of antimony oxide to the glass batch appreciably improves the gloss of the enamelled design. These glasses are somewhat similar to phosphate opals and appear to be of the 'emulsion type'. The possibilities of the manufacture of 'China Glass', an imported milk white glass used in the Indian glass bangle industry for decorating the bangles, are discussed.

## 200. Chemical examination of Indian pyrolusites in relation to their use in dry cell manufacture.

D. S. NAIDU *and* G. D. JOGLEKAR, Calcutta.

The paper deals with a study of the relationship between the chemical composition of pyrolusite ores and the electrical characteristics of cells prepared from them.

The results of analysis of a number of pyrolusite ores of Indian and foreign origin, and also of an artificial manganese dioxide are given.

The electrical characteristics of cells, prepared with these different pyrolusite ores and their admixtures with artificial manganese dioxide, under standardized and accurately controlled conditions, are measured under constant temperature and humidity conditions.

The electrical characteristics indicate that apart from chemical composition, water of hydration, which is present in varying proportions in these ores, plays an important part in determining their suitability as depolarizers.

The output of cells containing natural ores can be improved by admixing small proportions of artificial manganese dioxide which is comparatively rich in its water of hydration content.

## 201. The depolarizing action of Indian pyrolusites.

CHITTARANJAN BARAT *and* P. SEN GUPTA, Calcutta.

The depolarizing action of natural pyrolusites, appears to depend upon their chemical as well as physical compositions. On examination of various samples of natural pyrolusite as well as of fresh and exhausted dry cells, J. Meyer and R. Kanters (*Z. anorg. u. allg. Chemie*, 1930, *185*, 177) found that natural pyrolusites contain, besides MnO and $MnO_2$, varying quantities of $Mn_2O_3$ and $Mn_3O_4$, and during the process of cell-discharge, the dioxide present is never reduced below the stage of $Mn_2O_3$. This, combined with the fact that Caucasian pyrolusite and certain synthetic $MnO_2$, e.g. 'Manganit' (supplied by Messrs. Nikolas Branz of Germany), have greater depolarizing action than specimens with higher $MnO_2$ and lower Fe and Cu contents, led us to believe that the superior activity of the two previously named specimens is due to some special form of manganese oxide that possibly acts as an oxygen carrier. Investigations are being carried out with a view to determine this constituent as well as to assess the values of Singhbhum and other local varieties of pyrolusite, according to the methods described by the above authors, and to compare their compositions with those of authentic specimens of Caucasian and synthetic pyrolusites. The results, though tentative, reveal striking features, which, if properly utilized, may reasonably be expected to enhance the quality of the local 'Dioxide Ore' to a remarkable extent.

## 202. Some properties of Indian bentonites.

D. R. MITRA *and* A. REID, Digboi.

The chemical and physical properties of seven Indian bentonites are discussed and contrasted with those of a treated American bentonite. Of the seven, four are believed to be true bentonites; the others are sub-bentonites. Three are mixtures of alkali and alkali-earth bentonites while the American one is a true alkali bentonite. The fourth is a calcium bentonite readily converted to the sodium form by base exchange. With one exception the Indian samples give very stable suspensions at low concentrations. The exception is the calcium bentonite which on base exchange gives very stable suspensions. *p*H values of these suspensions vary with time but eventually become constant. Six of the samples pass the suggested MgO test for bentonite; the other, the calcium bentonite, easily passes after base exchange treatment. Thixotropy is developed to a varying extent by suspensions of the bentonites in water, that of the calcium bentonite being greatly enhanced on conversion to the sodium form. The samples show varying degrees of efficiency in increasing the viscosity of drilling fluids, none of them approaching in effectiveness the American product. The Indian bentonites can possibly be improved by suitable treatment and a few possible commercial uses are suggested.

## 203. Investigations into the suitability of some clays for activation.

J. L. SARIN *and* I. S. KUCKREJA, Lahore.

A number of clays from the Punjab have been studied with regard to their suitability for refining vegetable oils. In agreement with the statement in literature we found that earths with a dehydration curve (200°–600°C.) approaching a straight line are better suited for the purpose. The optimum temperature and time of heating the dehydrated earth with HCl (10%) are 110°C. and 12 hours respectively. Further work is in progress.

## 204. The manufacture of chromates from chrome-ion ore.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

In continuation of the previous work on reactions in a chromate furnace, it has been found that the oxidation of the chromite occurs necessarily through the formation of the intermediate compound which requires the addition of the basic oxide in the ratio of 1 : 1·5 for Cr : Ca. The previous data on the formation of sodium, calcium and magnesium chromates also indicate the formation of the compound $9RO . 4CrO_3 . Cr_2O_3$ corresponding to 33·3 per cent. decomposition of the original chromate, in good agreement with the results obtained in the decomposition experiments In practice calcium oxide in the ratio of Cr : Ca = 1 : 1·6–1·9 is used depending upon the percentage of $Cr_2O_3$ in the ore and the temperature of oxidation. Addition of larger quantities of CaO is recommended when the temperature is above 1100° because the intermediate compound formed at this temperature is $17CaO . 6CrO_3 . 2Cr_2O_3$, the ratio of Cr : Ca corresponding to this compound being 1 : 1·7.

The intensity of reaction between mixtures of chromates and carbonates to form intermediate compounds increases in the order: calcium, strontium and barium, and in fact barium carbonate can be used in preference to calcium carbonate in the process of chromate manufacture.

## 205. Wetting agents in textile processing. Part II. Methods of estimation.

R. B. FORSTER, I. S. UPPAL, *and* K. VENKATARAMAN, Bombay.

The Herbig-Evans apparatus for determining wetting power has been modified, eliminating possible changes in the interval between immersion and hydroextraction and enabling the estimation of wetting power at temperatures up to 100°C. Using the new apparatus the wetting power of a series of commercial products and the influence of factors such as temperature, concentration and time of immersion were studied.

Analytical methods for estimating the active agent present in a given textile auxiliary have been examined. Processes based on the solubility of fatty alcohol sulphates and sulphonates in alcohol and on salt formation with aromatic bases such as benzimides were alike unsatisfactory for certain substances. A titrimetric method using benzidine hydrochloride, in conjunction with the study of solubility relations, is under investigation.

The reaction described in Part I (*J. Soc. Dyers Col.*, 1937, *53*, 91) has been extended to other fatty acids and aromatic amines. Substances with properties improved in certain directions (solubility in water, wetting power, ability to disperse calcium soaps) have been obtained. For the purification of the condensation products, their solubility, both as free sulphonic acids and as sodium salts, in methanol and the higher alcohols was utilized.

## 206. Trisodium phosphate as a textile auxiliary.

F. F. DARBARY, S. R. RAMACHANDRAN, *and* K. VENKATARAMAN, Bombay.

Working with a commercial brand of the substance containing about 99% of $Na_3PO_4$, $12H_2O$, the utility of trisodium phosphate was examined as a water softener (for textile purposes), in addition to the kier for the boiling of undyed and coloured materials, as a substitute (partially and completely) for caustic soda in naphthol impregnation baths (e.g. in their application to wool and silk), in the hydrosulphite reduction of vat colours, and as a reagent (by itself and in admixture with soap, soda ash and wetting agents) for the after-treatment of cotton dyed with the insoluble azo colours. In relation to these processes, the properties of the substance,

such as solubility in water at different temperatures, alterations in moisture and carbonate content on storage, behaviour towards hard water, interfacial tension between the aqueous solutions and organic solvents, and wetting power as indicated by the flotation and Herbig number tests, are recorded.

## 207. The recovery and use of agricultural wastes. Part II.

G. Ramarao, Bangalore.

The shelling of cashew nuts in an indigenous industry of India. India imports about 28,000 tons annually from Africa and exports the finished nuts to America. This paper deals with the destructive distillation of the partially burnt shells. Valuable products have been obtained and their yields studied.

## 208. Utilization of myrobolan.

S. R. Sunthankar *and* S. K. K. Jatkar, Bangalore.

We have examined the fatty oil from the myrobolan kernel. The following are the various constants of the oil which forms 36 per cent. of the kernel: sp. gravity = 0·9132, refractive index = 1·4700, sp. rotation = −0·120°, saponification value = 190·2, acid value = 3·4, iodine value = 105·1, Hehner value—insoluble fatty acids = 96 per cent., and unsaponifiable matter = 1·15 per cent.

A study of the composition of the mixed fatty acids showed that the oil consists of 58 per cent. of olein, 24 per cent. linolein and 18 per cent. saturated glycerides.

## 209. Industrial utilization of the grass and leaves from *Vetiveria Zizanoides* Stapf.

J. L. Sarin *and* B. S. Gupta, Lahore.

Large quantities of this grass (locally known as panni grass) are found in the Punjab, about 60 to 70 thousand maunds being available in the Hissar District alone every year. Possibilities of utilizing this grass, at present a waste product, for the manufacture of paper have been investigated. The yield of dry pulp on the weight of the grass is from 25 to 30 per cent. The paper obtained appears to be of good quality. Further work is in progress.

An important bye-product obtained from the roots of this grass is the vitivert oil. The yield obtained is 0·3 to 0·4%. The constants of the oil as determined show that the oil compares favourably with the superior Java oil in quality.

## 210. Preparation of saponin from *Sapindus mukorossi* Gaertn (Soapnuts).

J. L. Sarin *and* M. L. Beri, Lahore.

A method for the extraction of saponin from soapnuts has been worked out which gives chemically pure saponin in good yield. It consists in refluxing soapnut-shell powder with ethyl acetate for 3 to 5 hours. After allowing to settle for some time ethyl acetate is drawn off. Three extractions with this solvent were found to be sufficient. The ethyl acetate extract is then distilled and the pale yellow residue left behind yields saponin on refluxing first with ether sulphuric, and then with benzene. The commercial possibilities of the process are being studied.

## 211. A solvent extraction method for winning sandalwood oil.

A. Nagaraja Rao, Cawnpore.

Ethyl alcohol has now been employed very successfully as a solvent in the winning of sandalwood-oil from sandalwood. A simple method of utilizing the ethyl alcohol even for the recovery of oil from oleo-resin, after having used the same solvent during the first stage of the winning of the oleo-resin from sandalwood, has now been very successfully worked out by the author by treating the latter with alcohol of suitable concentrations. It has also been observed that the oil obtained by this process is in every way superior to the oil obtained by the previous methods hitherto employed in the industry.

## 212. A study of the 'true' and 'apparent' colloids in molasses.

A. Nagaraja Rao, Cawnpore.

The author has attempted to determine the 'true' and the 'apparent' colloids present in cane-sugar molasses from the carbonation and the sulphitation factories. While a mere lowering of the viscosity of molasses brought about by dilution brings about the separation of the 'truly' insoluble matter in molasses, a carefully controlled dialysis is necessary to determine the total amount of 'apparent colloids'. The nature of the colloids isolated from molasses under these different conditions is subjected to a detailed examination so as to yield a correct insight into their nature, which would ultimately enable the whole process of clarification in the cane-sugar industry to be worked out more completely.

## 213. Studies on the action of solvents on Indian coals.

R. K. Dutta Roy, Calcutta.

The action of solvents namely benzene, tetralin and pyridine on Indian coals under pressure has been studied and the function of various factors concerning the process of extraction has been discussed. A comparative study between the properties of original coal and the residual coal after extraction has been made. The tetralin extract has been resolved into solid bitumen and oil bitumen and the important role played by them in the formation of cokes has been studied. Further, individual bitumen has been resolved into its constituent parts—some definite compounds have been obtained and attempts have been made to get a clue as to the structure of coal and its best industrial applications.

## 214. Influence of rate of flow on the formation of ozone.

R. Krishnan *and* S. K. K. Jatkar, Bangalore.

The ozonisor consists of two double walled pyrex vessels with an annular space of about 4 mm. connected in series and operated by the ordinary single phase balanced windings of the Neon Sign Transformer. Experiments were made to study the yield of ozone for various rates of flow of oxygen.

The curve showing the yield for various rates of flow is of the asymptotic form. It is however found that for a particular rate no ozone at all is formed.

For the same rate of flow the yield of ozone is less when two ozonisers are used in series than when a single ozonizer is used, but with an increased rate of flow the yield in the two ozonisers in series is slightly greater than in the single one.

## 215. Equilibrium in electrodeless discharge.

S. K. K. JATKAR *and* N. B. BHATT, Bangalore.

The action of high frequency electrodeless discharge in hydrogen has been studied at low pressures in pyrex and quartz tubes. The general nature of the clean-up phenomenon observed in hydrogen has been found to agree with the observations of previous workers and the results obtained show that the gas is first adsorbed on the walls of the tube, forming a mono-molecular layer on quartz surface, from which it can partly be recovered by subsequent heating. Further loss of the gas is found to be due to formation of water vapour by its action on silicon dioxide. The water vapour is found to be dissociated to the extent of 70 per cent., by the action of the discharge.

Under the same conditions as in the case of hydrogen, oxygen disappeared in very small amount, if at all, by a discharge through it and no ozone was found to have been formed.

Carbon dioxide was found to dissociate to the extent of 25 per cent. when it was dry and free from impurities. In presence of adsorbed hydrogen the dissociation seems to occur to the extent of 75 per cent.

## 216. Dielectric constants of mixtures of alcohol, benzene and water.

S. K. K. JATKAR *and* (MISS) NAGAMANI SHAMA RAO, Bangalore.

We have developed a simple, single circuit for measuring the dielectric constants at different frequencies, using quartz oscillators whose frequencies were determined with great accuracy. In the case of ethyl alcohol water mixtures, the nature of the graph showing the plot of dielectric constants of the mixtures against composition indicates the existence of complexes : (1) $EtOH . 1H_2O$, (2) $EtOH . 2H_2O$, and (3) $EtOH . 3H_2O$, and confirms the conclusion arrived at in the study of the conductivity of pure soaps in mixtures of alcohol and water carried out in our laboratory.

The dielectric constants of mixtures of isoamyl alcohol and benzene show a break in the curve at a composition corresponding to the formation of the complex $1AmOH . 5C_6H_6$. The refractive index and dispersion of the mixtures also support the formation of the complex. The velocity of esterification in mixtures of isoamyl alcohol and benzene is also a minimum at this composition.

## 217. Oxidation of hydroxylamine sulphate and hydrochloride by means of potassium permanganate.

C. C. SHAH *and* N. V. DHAKAN, Baroda.

In the reduction of nitric acid to ammonia, hyponitrous acid has been considered as an intermediate product (*Jour. Phys. Chem.*, 1926, *30*. 1222). But it has been shown by Partington and Shah (*Jour. Chem. Soc.*, 1931, 2071) that hyponitrous acid cannot be reduced to ammonia though it can be oxidized to nitric acid to a certain extent. Leaving out nitrogen, hydroxylamine should be the first reduction product of hyponitrous acid. In order to elucidate this behaviour, experiments have been conducted to study the oxidation of hydroxylamine by potassium permanganate.

The course of the oxidation of hydroxylamine by potassium permanganate in neutral solution can be represented by the following equations :—

$$5(NH_2OH)_2H_2SO_4 + 4KMnO_4 = K_2SO_4 + 4MnSO_4 + 2KNO_2 + 2N_2O + 2N_2 + 20 \cdot H_2O$$

$$5NH_2OH . HCl + 2KMnO_4 = KCl + 2MnCl_2 + KNO_2 + N_2O + N_2 + 10H_2O.$$

In acidic solution, the course of the oxidation is represented by the following equations :—

$$5(NH_2OH)_2H_2SO_4+10KMnO_2+10H_2SO_4 = 5K_2SO_4+10MnSO_4+8HNO_3 +N_2+26H_2O.$$

$$10NH_2OH \cdot HCl+10KMnO_3+20HCl = 10KCl+10MnCl_2+8HNO_3+N_2 +26H_2O.$$

The course of the oxidation is dependent on the concentration and the $p$H value of the solution. Temperature has little effect on the course of reaction.

It appears from the results so far obtained that the velocity of the oxidation reaction is very small.

## 218. Formation and properties of polyiodides.

M. D. AVASARE *and* A. M. TRIVEDI, Baroda.

(i) Phase rule study of the system ammonium iodide—iodine-carbon tetrachloride at 30°C. showed the formation of a compound ammonium tri-iodide ($NH_4I_3$), as confirmed by quantitative examination.

Treatment of an aqueous solution of ammonium iodide of definite concentration with iodine results in the formation of ammonium penta-iodide—a very hygroscopic and unstable compound.

(ii) A detailed study of the solubility of iodine in aqueous solutions of potassium, ammonium and sodium iodides shows that (*a*) potassium tri-iodide, ammonium tri-iodide and sodium tri-iodide are only formed when the salt solutions of concentration range 0·05M to 0·7M per litre approximately, are employed; (*b*) potassium heptaiodide, ammonium heptaiodide and sodium heptaiodide are formed when the concentration of the alkali iodides, is between 4M and 5M per litre approximately; and (*c*) there is also evidence to indicate the formation of potassium penta-iodide, ammonium pentaiodide and sodium pentaiodide over the alkali iodide concentration range 1·8M to 2·8M per litre approximately.

(iii) A preliminary investigation on the reactivity of iodine in presence of alkali iodides, in a system containing iodine, alkali iodide, acetone and water has shown that the iodide is held by the alkali iodides with fairly strong molecular forces.

## 219. Investigations on hyponitritosulphates.

C. C. SHAH *and* N. V. DHAKAN, Baroda.

Pure potassium hyponitritosulphate has been successfully prepared and its chemical reactions have been studied. The following equations represent the course of its spontaneous decomposition :—

$$K_2SO_5N_2 = K_2SO_4+N_2O \quad \ldots \quad (1)$$

$$K_2SO_5N_2 = K_2SO_3+2NO \quad \ldots \quad (2)$$

The course of the reaction has been found to depend on the concentration, temperature and the $p$H value of the solution. In ordinary air, the solid salt decomposes, mainly according to equation (1). Anhydrous carbon dioxide has no effect upon the salt. In saturated water vapour, the salt decomposes rapidly into sulphate and nitrous oxide. The aqueous solution of the salt is unstable and decomposes according to equation (1). All kinds of acids decompose the salt in the same way, i.e. in accordance with equation (1), but alkalies appear to have a stabilizing influence on the salt.

In acidic solution, potassium hyponitrosulphate is neither oxidized by common oxidizing agents such as potassium permanganate, iodine, bromine, sodium bromate, hypoiodite, hypobromite, etc., nor reduced by reducing agents such as stannous chloride and hydrochloric acid, sodium bisulphite and hydrochloric acid, zinc and acetic acid, etc.

In alkaline solution, potassium permanganate and sodium hypochlorite oxidise it with the formation of potassium sulphate and nitric acid; all the nitrogen does not, however, get converted into nitric acid, some of it escapes as nitrous oxide.

By the action of alkaline reducing agents a very small amount of ammonia is formed and a variety of products such as hydrazine, potassium sulphite, sulphate, etc. are detected in the reduction products.

The results obtained so far show that the hyponitritosulphuric acid, probably exists in two forms:

$$HO.SO_2.NO : N.OH \quad \ldots \quad (1)$$

$$HSO_3.N.ON.OH. \quad \ldots \quad (2)$$

Sodium and ammonium hyponitritosulphates and the double salts of zinc, cobalt, manganese, cadmium, silver and barium have also been prepared.

## 220. Studies in salting out effect.

M. D. AVASARE *and* C. B. PATEL, Baroda.

In the studies on the salting out of iso-amyl alcohol, iso-butyl alcohol, aniline and *o*-toluidine from aqueous solutions by different salts it has been found that the hydration of a salt in solution is largely responsible for its salting out power. In addition, the ions resulting from the salts are also found to exhibit specific salting out power. Kations and anions are assigned a definite order with respect to their salting out capacity, viz.:

$$Na^{\cdot} > K^{\cdot} > Li^{\cdot} > NH_4; \quad Ba^{\cdot\cdot} > Ca^{\cdot\cdot}; \quad \text{and} \quad Cl' > Br' > NO'_3$$

The salting-in of aniline and *o*-toluidine by ammonium nitrate is attributed to the formation of an additive compound between the solute and the salt.

## 221. Composition of boiled oil.

M. GOSWAMI *and* A. SAHA, Calcutta.

Conjugated double bonds in linseed oil get rearranged when boiled under commercial conditions in presence of catalysts. This view was advanced by one of us in *Science and Culture* (1935, *1*, 183) and has now been experimentally confirmed by actual determination of Dien value as defined by Kaufman and Baltes (Felte, *U. Scifen*, 1936, 93). Manganese oleate, nickel oleate, nickel rosinate have been used as catalysts and the Diene values have been determined.

# SECTION OF GEOLOGY

*President* :—D. N. WADIA, M.A., F.G.S., F.R.G.S., F.N.I., F.R.A.S.B.

## General

### 1. The structure of the Shali 'window' near Simla.

W. D. WEST, Calcutta.

The Shali window is located immediately north-east of Simla. Two tectonic units occur, (1) an overlying slightly warped sheet composed of rocks of the Chail series, probably Pre-Cambrian in age, and (2) an underlying folded series of rocks comprising the Shali series, Madhan slates, and Tertiary beds (Eocene and Miocene).

The two units are separated by a plane of marked discordance. Thus whereas on the south side of the window the Chail series rest directly on Tertiary beds or Madhan slates, on the north side they rest on the lower part of the Shali series. In the interval, 4,000 feet of rock have disappeared.

That severe disturbance has occurred along the plane of junction of the two units is clear from the presence of small recumbent folds and thrusts in the uppermost rocks of the lower unit. Further, not only are the Chail series definitely older than the rocks that come below, but their grade of metamorphism is distinctly higher.

It is concluded that the rocks above the discordance have been forced many miles to the south along a nearly horizontal thrust plane over younger autochthonous rocks during post-Miocene times. Subsequent denudation has removed the overlying rocks and revealed the younger rocks beneath. The plane of discordance has been termed the Shali thrust. It must continue beneath Simla, and very probably joins up with the Giri thrust near Kandaghat.

### 2. Post-Siwalik thrusts in the Punjab sub-Himalayas.

H. M. LAHIRI, Calcutta.

The paper records the occurrence of two parallel thrust-faults observed by the writer, one along the south-west base of the Siwalik range north of Rupar where the Sutlej debouches on the Hoshiarpur and Ambala plains and the other at the foot of the Nalagarh hills about fourteen miles to the north-east of the former. As the result of the first of these, the Upper Siwalik rocks north of the Sutlej are seen pushed over the horizontal Older Alluvium of the Indo-Gangetic plain. The age of this thrust is sub-Recent at the oldest. The Nalagarh thrust is probably somewhat older, with brecciated Nahan (Lower Siwalik) rocks thrust on almost undisturbed Upper Siwalik boulder-gravels and clays of the *dun* area to the south-west. This thrust is of especial interest as, at places, the Nahan beds are seen to have travelled over the boulder-gravels for considerable distance from the base of the hills.

### 3. Preliminary account of the Shaksgam expedition, Karakoram Range.

J. B. Auden, Calcutta.

An expedition under the leadership of Mr. E. Shipton, and including H. W. Tilman, M. A. Spender, topographer, and J. B. Auden, geologist, crossed the Karakoram range in May, 1937, by the West Muztag pass and descended into the Sarpo Laggo valley. From here topographical mapping and geological traverses were carried out along the Shaksgam river and over the Aghil Ranges northwards to the Yarkand river. After returning to the Sarpo Laggo valley, the Crevasse glacier, first found by Younghusband in 1889, was explored up to its head, a distance of about 30 miles from the snout. A return was made by Auden in August over the Karakoram watershed and down into the Punmah glacier. Part of the Shaksgam and Sarpo Laggo valleys had already been examined by the geologist Desio during the Spoletto expedition of 1929.

A syncline of probable Jura and Cretaceous rocks and undoubted Permo-Carboniferous occurs along the Shaksgam and southern Aghil ranges. Below the Permo-Carboniferous and extending northwards to the Yarkand river and the Kun Lun, and southwards into Baltistan, there is found a series of dark phyllites, grey-wackes and quartzites, with subordinate limestones. Red beds occur along the Zug Shaksgam and Surkwat rivers, and may be equivalent to the Tisnab series of DeTerra (Lr. Carboniferous).

Contrary to what Auden believed in 1933, he now considers it probable with Desio, that the highly metamorphosed schists, granulites and marbles which are found near Askole and up the Biafo glacier are Palæozoic in age, and contemporaneous with the less metamorphosed rocks of the Palæozoic sequence of the Aghil ranges. The metamorphism may have developed during the Tertiary along zones where the compressed geosyncline was forced downwards into levels of higher isogeotherms and more intensive granitization.

Post-Carboniferous granites and lamprophyres have invaded Permo-Carboniferous and older rocks, the latter being particularly prevalent just north of the peak of K2.

The late Cretaceous and early Tertiary volcanic suite of Dras and the Burzil valley extends over a considerable part of the Deosai plains.

### 4. An outline of the structure and tectonics of Peninsular India.

M. S. Krishnan, Calcutta.

The structural trend-lines of Peninsular India, which are the directions of the major fold-axes, are the following :—

1. The Eastern Ghats strike (N.N.E.-S.S.W. or N.E.-S.W.) extending from the Shillong Plateau to near Madras where it gradually swings round into the Nilgiris with an E.N.E.-W.S.W. trend.
2. The Godavari strike (N.W.-S.E.) seen along the Godavari and Mahanadi valleys and in the Bastar State and the neighbouring parts of the Central Provinces.
3. The Satpura strike (E.N.E.-W.S.W.) found over southern Bihar and the northern parts of the Central Provinces.
4. The Aravalli strike (N.E.-S.W.) prevalent over Rajputana and Northern Bombay. It is probably continuous with the Western Ghats down to Cape Comorin, but with a change in direction (N.N.W.-S.S.E.). Parts of Hyderabad and Mysore belong apparently to its area of influence.

The Peninsular structural lines—those of Aravalli, Satpura and Eastern Ghats—are frequently found in the Sub-Himalayan region.

The most important faults which have affected the Peninsula are :— One along the western coast and the other along the Mekran-Baluchistan coast ; those along the courses of the Narbada and the Tapti ; the Great Boundary Fault of Rajputana separating the Uppor Vindhyans from the older rocks ; the Ellichpur fault ; one along the southern margin and possibly another along the northern margin of the Shillong Plateau ; those bordering the Cuddapah basins on their concave margins : the trough faults which have let down the Gondwanas into the ancient rocks and which are distributed along three linear tracts, viz., the Damodar-Son, the Mahanadi and the Godavari valleys.

## 5. Pleistocene glaciation in north-western India, with special reference to the erratics of the Punjab.

A. L. COULSON, Calcutta.

After considering the distribution and nature of occurrence of the long-debated erratics of the Punjab, it is concluded that if, as Cotter has suggested, a catastrophic flood was responsible for bringing them to their present positions, then that flood took place before the final dismemberment of the Indobrahm. It is suggested that the erratics more probably were transported by floes, breaking off from the snouts of glaciers and remaining unmelted sufficiently for the erratics to reach their present positions by floating down a quiet lake. Later earth movements took place which were responsible for the final dismemberment of the old Indobrahm and caused the Indus to find a new course through the Attock and Kalabagh gorges.

By comparing the evidence of Pleistocene glaciation near the Pir Panjal and in Hazara, it is obvious that the Pir Panjal must have received its major elevation after the main glaciation had occurred. Thus the general statement that there is no evidence of glaciation in the Himalaya and Sub Himalaya below 5,000 feet must be discounted in view of the fact that elevation of these ranges has occurred after the main glaciation.

Attention is drawn to the possible part-glacial origin of certain boulder beds in the Siwaliks, as exemplified by the Bain boulder bed, considered by Morris to be derived from the melting of an ice tongue which extended eastwards from the highlands of Waziristan in late Pliocene to Pleistocene times. Record is made of the recent discovery by the author of two possible and one doubtful artefacts from the Bain boulder bed near Akbari in the Dera Ismail Khan district of the North-West Frontier Province.

## 6. The mid-Palæozoic land-bridge of Kashmir.

D. N. WADIA, Calcutta.

The Palæozoic sequence of North-West Himalayas contains a long mid-Palæozoic break from Devonian to Middle Carboniferous, the *hiatus* representing a more or less uninterrupted land period in N.W. Punjab, Hazara, Karnah and Gilgit region, as far north as the Pamirs. At the commencement of the Upper Carboniferous also, terrestrial conditions prevailed in Kashmir supporting a land flora of Lower Gondwana type, up to Lat. 34° 30′. There was no Uralian Ice Age in Kashmir, it being replaced by a long and intense local volcanic period. The Punjab-Kashmir land-mass must have served as a land-bridge between Angaraland and the future Gondwanaland, affording a route for the migration of terrestrial vegetation just prior to, and in the earlier stages of, the Gondwana period.

In South-East Kashmir and in the Spiti Himalayas, on the other hand, there is a continuous and conformable marine Palæozoic succession from the Cambrian to Permian, the unconformity beginning to appear west of Long. 74° 30′.

7. The structural significance of a fault in the upper Bhima series (Vindhyans) between Honhalli (Lat. 16° 44′ 55″, Long. 76° 26′ 10″), Makhtapur (Lat. 16° 45′ 30″, Long. 76° 49′ 50″), and Radewadgi (Lat. 17° 4′, Long. 76° 47′ 30″) in the Bhima basin in Gulberga district.

C. Mahadevan, Hyderabad (Deccan).

The classification of the pre-Cambrian sedimentation in the Bhima basin into a higher and a lower group is not arbitrary but there are stratigraphic reasons to support it.

A well-defined fault about 50 miles long has been traced running roughly east to west between Honhalli and Makhtapur, with a north to south trend between Makhtapur and south of Radewadgi. Besides affording clear evidence of the time-lag suggested by Bruce Foot between the Lower and Upper Bhima Series, the fault throws interesting side-light on the level oscillation in the Upper Bhima stage. The paper discusses the significance of the fault in the stratigraphy of the Bhima Series.

8. Origin of the Himalayas.

S. L. Biswas, Calcutta.

The field evidences clearly imply a crustal movement from the North. The Sliding Continent Theory provides sufficient crustal shortening for producing this mountain system and explains its structural features as well as the later development of the Southern foot-hills, marked by the series of ‘Boundary faults’. The nature of the Northern border of Peninsular India had much to do in the shaping of the range. Removal of water from the Tethys area must have submerged other parts of the earth.

9. An exhibit showing the formation of autoclastic conglomerate.

W. D. West, Calcutta.

In the Sausar series (Archæan) of the Central Provinces there occur at certain horizons what have been called by Sir Lewis Fermor ‘tabloid’ or ‘pebbloid’ schists. Detailed examination has shown that the ‘pebbles’ have been formed in rocks that were composed of alternating hard and soft beds. The harder sheets were first sheared out into flat lenticles, and were subsequently broken up and rolled out into ‘pebbles’. These may be flat, or almost spherical. They commonly contain sillimanite.

In some cases injection gneisses have been similarly affected, the injected aplite bands playing the rôle of the harder sheets and providing the ‘pebbles’.

10. Geology of Khurda, Puri district, Orissa, and its neighbourhood.

P. K. Chatterjee, Calcutta.

The area is mostly covered with alluvium and laterite. The hills near Goradharmasagar and Barunai consist of garnet-sillimanite schists (Khondalite). Near Barunai hill, an exposure of garnetiferous granitoid gneiss is found. In the neighbourhood of Kurarhmal, granite with coarse texture is visible and the same rock in its eastward extension is rich in hypersthene and is finer-grained. On the north of this hill, there is a fine-grained garnetiferous quartzo-felspathic vein found to extend in a E.N.E.-W.S.W. direction. To the south of the granite hill, there is an exposure of dioritic rocks rich in hypersthene traversed by a fairly wide

quartz vein. Quartzite shows jointing well. It is associated with a thin band of psilomelane.

Laterite is worked in a quarry south of Khurdagarh, both for building purposes as well as for smelting. Psilomelane from the quartzite hillock is locally utilized by the smelters for manufacturing indigenous steel products. Clay derived as a decomposition product is used for domestic purposes.

The khondalites of this area are comparable with those of the Kalahandi State and Ceylon.

### 11. On a seismometric study of the Bihar earthquake of January 15, 1934 and its aftershock of January 19, 1934.

S. C. Roy, Rangoon.

An account is given in this paper of a seismometric study of the disastrous earthquake of Bihar on January 15, 1934 and of one of its aftershocks on January 19. The main conclusions are :

1. The earthquake was initiated by a minor failure near Lat. 26° 18′ N. and Long. 86° 18′ E., the time of origin of the first preliminary tremors being 8h. 43m. 21s. G.M.T. The culminating major crash, which occurred about 11s. after the initial minor rupture and about 5s. to 7s. after an intermediate stage, had its origin near Lat. 26° 21′ N. and Long. 86° 21′ E. close to Madhubani. The progression of the fractures east-north-eastwards from the minor to the major stage suggests that the stresses no longer supported at the origin of the major crash were transferred from Madhubani area more towards Sitamarhi than towards Purnea.

2. The epicentre of the aftershock of January 19 is located near Lat. 26° 24′ N. and Long. 86° 18′ E. which is close to the seismometric epicentre of the main shock.

3. A list of the aftershocks which were registered by instruments both at Alipore and Agra indicates that their frequency declined very rapidly. This rapid decline is interpreted to mean that nearly complete relief was afforded by the main shock of January 15.

4. The extra-ordinary development of long waves and the presence on the Indian seismograms of pulses characteristic of near earthquakes with shallow focal depth, suggest that the main earthquake of January 15 originated in the uppermost layer of the earth's crust.

The focal depth and the thicknesses of the uppermost and the intermediate layers of the earth's crust in Bihar have been calculated from the apparent delays in starting of the various pulses with respect to the fundamental distortional wave travelling directly from the focus to the observing station. The values found are :

Focal depth = 14·8 kms.
Thickness of Granite = 14·8 kms.
Thickness of Basalt = 25·4 kms.

It is concluded that the primary cause of the earthquake lay near the interface of the Granitic and the Basaltic layers.

## Stratigraphy

### 12. The heavy minerals of the Assam Tertiaries.

P. Evans *and* M. A. Majeed, Digboi.

Examination by the Burmah Oil Company geologists of the 'heavy minerals' in the 50,000 feet of sedimentary rocks which make up the Tertiaries of the Assam-Arakan belt has shown that over a very wide area there is a remarkable degree of correspondence in the general character of the mineral suites. The earliest beds have a small heavy mineral content

and the number of mineral species is limited. In successively younger beds there is a steady increase in the complexity of the mineral assemblages and in the total proportion of heavy minerals. The order of appearance of the various different minerals is nearly the same over a large area, and certain well-defined 'markers' formed by fairly abrupt changes in the proportions of hornblende, epidote, and some other minerals can be traced for many miles.

## 13. On the extent of the Niniyur division in the Trichinopoly Cretaceous area.

L. RAMA RAO, Bangalore.

In the light of his recent work on the uppermost beds of the Trichinopoly Cretaceous area (L. Rama Rao and Julius Pia: On the algæ from these beds—*Pal. Ind.*, N.S., Vol. XXI, Mem. No. 4, 1936.) L. Rama Rao and C. Prasannakumar: On the flints and cherts from these beds—*Proc. Ind. Acad. Sci.*, Vol. I, No. 1, 1934) the author, in the present paper, shows that the post-Senonian transgression of the sea which gave rise to these beds (the Niniyur division) must have covered a long strip of country on the eastern side of the Trichinopoly Cretaceous area—from Authencoorchy in the north to Vilangudi in the south.

## 14. Unconformities in the outer Himalaya.

J. B. AUDEN, Calcutta.

The paper discusses the existence of unconformities in the geological succession of the Outer Himalaya between Solon and Lansdowne. The following unconformities have been recognized :—

(1) At the base of the Eocene, which lies variously on the Simla slates, Krol limestones and Tal series (Jurassic).
(2) At the base of the Tal series.
(3) At the base of the Blaini series.
(4) At the base of the Nagthat series.

The Nagthat (Jaunsar) series is pre-Blaini in age and therefore probably pre-Uralian. It is regarded as continental in origin and as equivalent to the Tanawal series of Kashmir. The unconformity at the base of the Nagthat series may be compared with that described by Wadia in north-west Kashmir and suggests a continuation to the south-east of the Kashmir-Hazara-Punjab land-mass. De Terra has described the Tisnab beds of Southern Chinese Turkestan as a continental series of rocks of Lower Carboniferous age, while Auden has found somewhat similar red rocks in the Aghil range. It seems probable that continental conditions may have prevailed during late Devonian and early Carboniferous times over a considerable area in Northern India and Southern Turkestan and gave place later to the widespread Permian marine transgression.

## 15. On the age of the Deccan trap as evidenced by fossil fish-remains.

S. L. HORA, Calcutta.

The systematic position of the fossil fish-remains from the infra-trappean beds at Dongargaon and from the inter-trappean beds at Takli, Paharsingha, Deothan and Kheri along with their known geological ages are tabulated. The distribution in space and time of the 10 principal types of trappean fishes is discussed, and it is concluded that these beds were probably laid down in the early Tertiaries when the land connection between India and Africa had already disappeared and when the area occupied by the beds was not very far from the sea-coast. It is further

pointed out that there was probably sufficient interval between the formation of the infra- and the inter-trappean beds to permit the change from a predominantly Ganoid fauna, comprising *Lepidosteus* and *Pycnodus* of the Lameta beds at Dongargaon, to a fauna of almost exclusively Teleostean fishes, such as the Clupeidæ, the Osteoglossidæ, the Cyprinidæ and a great variety of Acanthopterygians, in the inter-trappeans at Deothan and Kheri.

From an ecological point of view one thing seems fairly certain that the conditions usually associated with a large and deep river characterized the infra-trappean period, and that by the advent of the inter-trappean period marshy conditions, usually associated with the mouths of large rivers, had set in.

## 16. A note on the correlation of late Tertiary marine deposits of India.

A. K. DEY, Calcutta.

A difficult problem in Indian stratigraphy is the correlation of late Tertiary marine deposits in widely separated areas. The method usually employed is based on the specific identity of the fauna. But the discrimination between species is largely dependent on the judgment and experience of the worker. The stratigraphical range of species is becoming wider than was formerly supposed. Percentage methods of correlation are of doubtful value unless ecological factors are also properly estimated. To overcome these difficulties, it is best to look, in addition, for some structural modifications undergone by a genus during its successive stages of evolution. The evolutionary stages would clearly be the best guides in correlation. The discovery of *Placenta lamellata*, n.sp., in the Neogene fauna of Quilon, showing a new stage of evolution of the genus *Placenta*, has rendered valuable aid in the correlation of the fauna.

## 17. A preliminary account of the petrology and age of the rocks (the Deccan trap) of Elephanta island, Bombay.

A. S. KALAPESI *and* R. N. SUKHESWALA, Bombay.

The island of Elephanta (18° 58′ N. : 72° 58′ 30″ E.) lies at a distance of about seven miles east of the Bombay island.

The island is entirely covered by the plateau-basalt (Deccan trap flows) which covered a large portion of Peninsular India in the beginning of the Tertiary era. The microscopic study of these rocks revealed two distinct varieties of lava flows, viz. andesite and basalt. Amygdaloidal basalt is also present. The caves are carved in this trap rock.

The main object of the present paper is to show the presence of rock types other than the normal basalt and also to deduce the geological age of the Deccan lava flows from the microscopic and analytical studies of some specimens collected from this area. The method adopted for age determination is the 'lead-ratio' method. Three different samples were analyzed for uranium, thorium and lead. Volumetric determination of uranium was carried out, while thorium was estimated gravimetrically. Lead was determined colorimetrically. Care was taken to select, as far as possible, fresh specimens for analysis. The maximum age calculated is 76 million years which agrees well with the geological age Lower Tertiary assigned to these rocks on stratigraphical and palæobotanical evidence.

## 18. Tertiary basalts of Bombay island.

V. S. DUBEY, Benares.

The Deccan trap is divided into 3 horizons, lower, middle and upper. The Bombay rocks, especially of Malabar hill, are supposed to belong

to upper flows. In the Bombay island there is also a long exposure of acid rocks. These acid rocks are later in age than the Deccan trap. But the authors found that these acid rocks are cut by basic dykes, which on analysis are found to be of similar composition to that of Malabar hill basalts. These dykes as well as the rocks of Malabar hill differ to some extent from the typical Deccan trap. The inter-trappeans below the Malabar hill flows have also yielded pebbles composed of acid rocks, found plentifully in Bombay, thus proving that the acid rocks are older than the Malabar basalts. The field evidence shows that these acid rocks are much later than the typical Deccan trap and that considerable denudation had taken place before these acid rocks were intruded. From the study of the other acid intrusions on the Western coast it appears that these acid rocks belong to Middle Tertiary age. Hence Malabar basalt, which is supposed to belong to Deccan trap, is later than these acid roeks of Middle Tertiary age.

## Palæontology

### 19. Discovery of the Lower Trias at Na-hkam, Northern Shan States, and descriptions of its fauna.

M. R. SAHNI, Calcutta.

The author records his discovery of the first and only Lower Triassic fauna known from Burma, including the Shan States. With few exceptions the Na-hkam fauna contains the only ammonites discovered in Burma. The fauna is unique in many respects. (1) Complete absence of the calcareous brachiopods, which are extremely common in the older formations. (2) The only brachiopod present is the corneous *Lingula*. (3) Ammonites, a group of which hardly any specimens have been found in Burma, predominate. (4) Practically the only other fossils found are lamellibranchs, grastropods and annelid remains.

The fauna bears a remarkable resemblance in its general composition to the East Greenland fauna described by Dr. L. F. Spath.

The similarity is probably due to similar shallow water conditions. Affinities with the Himalayan Lower Trias are indicated by a number of forms. Amongst the ammonite genera represented are *Ophiceras* (*Glyptophiceras*, *Lytophiceras*), *Vishnuites*, *Para-Vishnuites*, *Hemiprionites*, *Juvenites*, *Aspenites*, *Kashmirites* and doubtfully *Owenites*. The first new ammonite genus of the Shan Trias—*Heronites*—is proposed.

The lower part of the Lower Trias and possibly the base of the upper part of the Lower Trias are represented. Correlation with the Himalayan Lower Trias is put forward.

The southern limit of the Lower Triassic sea was not far from Na-hkam.

There is an entire change in fauna since the deposition of the underlying Permian rocks, and this suggests a profound physiographical break near the top of the Permian, for the lowest Triassic beds appear to be represented.

### 20. Devonian faunas from Meso, Taungtek and the intervening area, Southern Shan States, Burma.

M. R. SAHNI, Calcutta.

The author records the discovery of Devonian faunas from the Shan States, being the only record since T. H. D. La Touche's classical find at Padaukpin, Northern Shan States, thirty-five years ago. These faunas contain the only Devonian fossils known from the Southern Shan States.

The fossils occur in the lower, dolomitic division of the Plateau Limestone which covers vast areas in the Shan States, China, Burma proper and Siam and attains an enormous thickness. The author draws

attention to the almost universally unfossiliferous character of this series owing to its nearly complete dolomitization and brecciation. He emphasizes the one-sided character of these faunas. Brachiopods build up the major part, while mollusca are conspicuous by their absence. He explains this on the basis of the composition of the shell.

Amongst the fossils found are *Spirifer* (*Reticularia*) *curvatus* Schloth, *Sp.* (*Reticularia*) *aviceps* Kays., *Cyrtina heteroclyta* Defr., *Orthis* (*Schizophoria*) *striatula* Schloth., *Spirifer speciosus* Schloth. and var. *mesoensis* nov., *Atrypa reticularis* Linn., *Leptaena rhomboidalis* Wilck, *Calymene* cf. *malaungkaensis* Mansoy, etc. *Rhynchonella thannooensis* sp. nov., *Platyceras kachinensis* sp. nov., *Pleurotomaria lihsawensis* sp. nov., *Meristella palaungensis* sp. nov., etc.

The beds are divisible into two horizons, a lower, in which *Atrypa reticularis* occurs profusely, and an upper in which this well-known fossil is absent. A hard compact limestone near the top of the upper part is lithologically distinct from beds composing the other two divisions.

Older horizons may possibly be represented in the lower part of the series.

## 21. Palæontological study of belemnites from the Jurassic rocks of Cutch.

RAJ NATH, Benares.

While attempting to sub-divide the Jurassic rocks of Cutch into zones during field work in the year 1927, a large collection of invertebrate fossils was made by the author. The study of the belemnites has disclosed that there are two new species in the collection. The knowledge of the zonal distribution of the remaining ones adds to their stratigraphical value.

## 22. Corals from the Jurassic rocks of Cutch.

RAJ NATH, Benares.

During the course of field work in the year 1927 when a zonal subdivision of the Jurassic rocks of Cutch was being attempted, an extensive collection of fossils was made bed by bed. The corals in this collection form the subject-matter of this paper. Among the forms described, there is a new species (*Stylina soorkaensis*)—the only one found from the Umia beds. This new find necessitates the extension of the upper limit of the geological range of the Jurassic corals of Cutch from Argovian to Tithonian.

## 23. On the Infra-trappeans (Bagh beds) of Jhabua and Ali Rajpur States, Central India.

P. N. MUKERJEE, Calcutta.

During recent geological survey of the Jhabua and Ali Rajpur States of Central India, a collection of fossils was made from the Infra-trappeans (Bagh beds), the representatives of which have been already described by F. Stoliczka from the Cretaceous of South India. The discovery of some of the characteristic Upper Cretaceous forms, namely, *Protocardium pondicherriense* d'Orbigny, *Cardium* (*Trachycardium*) *incomptum* Sowerby, *Macrocallista sculpturata* (Stoliczka), *Crassinella trigonoides* (Stoliczka) and *Turritella* (*Zaria*) *multistriata* Reuss, in the Bagh beds of Central India, is of great stratigraphical importance regarding the upper limit of the age of the Bagh beds, and is in full agreement with the results obtained by Von Heune and Matley, who, from their investigation of the Dinosaurian remains in the Central Provinces, fixed the age of the Lameta beds (the fresh water equivalents of the Bagh beds) as Upper Senonian. Again, the presence of two Cenomanian forms in the collection, namely, *Grotriana* cf. *jugosa* Forbes and *Crassinella* cf. planissima (Forbes) indicates a

Cenomanian age, which has been already established by previous workers in the type area. It is, therefore concluded from the present investigations that the age of the Bagh beds range from Cenomanian to Upper Senonian.

## 24. On a *Palæoloxodon namadicus* mandible.

D. K. CHAKRAVARTI, Benares.

The mandibular rami and the piece of tusk described in this paper formed parts of a skeleton of an adult male Narbada Elephant, discovered in the Kankar bed of a small streamlet, flowing over the Vindhyan country in the south-eastern corner of the Allahabad district. Each ramus carries a molar, the last of the series. The molar implanted in the right ramus shows thirteen ridge-plates on the worn surface of the crown. The enamel layer is thin and as a rule free from crenulations. The piece of the tusk measures 190 mm. across the maximum diameter of its elliptical cross section and 110 mm. across the minimum. The distribution of this species in India and outside is discussed in the paper.

## 25. The upper Jurassic brachiopoda of the Bannu district, N.W.F.P.

M. R. SAHNI, Calcutta.

This paper deals mainly with a terebratellid fauna of Upper Jurassic aspect found in the Bannu district.

Underlying this is a sandy limestone formation (Shekh Budin Limestone) containing species of *Burmirhynchia* and doubtful *Daghanirhynchia* of Callovian age, which is separated from the terebratellids by 500 feet of strata. Occurring in the same bed as the terebratellids, but about four feet above them are certain ammonites identified by Dr. L. F. Spath as of Neocomian age. This creates an anomaly owing to the Upper Jurassic affinities of the main brachiopod fauna. There is no break between the Shekh Budin Limestone and the terebratellid fauna or between the latter and the ammonites.

The age of the underlying Shekh Budin Limestone containing *Burmirhynchia* is discussed. The author disagrees with the view of the French geologists that the age of the formations containing species of *Burmirhynchia* should be lowered from the Upper Jurassic to the Norian division of the Upper Trias.

*Burmirhynchia* occurs in slightly older rocks in Europe and the European origin of the genus, in spite of its name, is postulated. Amongst the new species described are *Ornithella coulsoni, O. indica, O. depressa, O. ovalis, O. paralagenelis, Kingena punjabica* '*Terebratula*' *bannuensis, Rhynchonella* (*Daghanirhynchia*) *coulsoni* and *R.* (*Daghanirhynchia*) *pezuensis*.

A provisional correlation with the Oxfordian-Kimmeridgian is suggested.

The comparative value of techniques in exposing the internal structures of brachiopods is discussed.

## 26. Palæontological study of gastropods from the Cretaceous beds of Trichinopoly.

RAJ NATH *and* M. P. NAITHANI, Benares.

With an idea of working out a more detailed stratigraphical sequence of the Cretaceous rocks of South India, a large collection of invertebrate fossils was made bed by bed from the outcrop of these rocks in the Trichinopoly district. The gastropods from this collection were taken up for palæontological study, which has revealed the presence of some new

**species. This has also helped in the revision of the geological distribution of certain species.**

## Mineralogy

### 27. Mineralization at Mawchi, Southern Shan States, Burma.

J. A. DUNN, Calcutta.

The Mawchi area consists of slates with some marbles, intruded by a large granite mass. The tin-wolfram deposits occur in each of these rock types.

The ore bodies are of cassiterite and wolfram with variable proportions of gangue minerals. The commencement of crystallization of each mineral was according to the following sequence: garnet, zoisite, fluorite, orthoclase, tourmaline, wolfram, cassiterite, beryl, phenacite, molybdenite, quartz, arsenopyrite, pyrite, sphalerite, stannite, chalcopyrite, bismuthinite, galena, scheelite, calcite, muscovite (including lepidolite), chlorite.

Scheelite is largely formed by the late replacement of wolfram. Secondary minerals include covellite and chalcocite.

The granite also contains, in places, grains of cassiterite which can be detected in thin sections.

Mineralization appears to have been continuous from a late stage in the crystallization of the granite itself, down to deposition of chlorite.

### 28. A chemical and mineralogical study of a new titanium mineral from Nellore.

N. JAYARAMAN *and* K. R. KRISHNASWAMI, Bangalore.

A detailed study of the mineral comprising the black magnetic inclusions in the garnets of the schist complex of Nellore has been conducted with a view to ascertain its mineralogical and chemical significance. The paper deals with the microscopic and chemical data concerning the mineral with a description of the methods employed. The chemical and mineral compositions are given in tables. They show a very high percentage of $TiO_2$ which is in excess of that required for normal ilmenite. The various hypotheses so far advanced to account for this excess of $TiO_2$ and for the existence of systems like $FeTiO_3$-$TiO_2$, $FeTiO_3$-$Fe_2O_3$, $FeTiO_3$-$Fe_3O_4$ and $FeTiO_3$-$Fe_3O_4$-$TiO_2$ are discussed. From the more or less homogeneous nature of this mineral, its high titanium content, and its strongly magnetic property, it is concluded that this mineral is a well defined type, probably belonging to a new system of minerals having the composition $FeTiO_3$-$Fe_3O_4$-$TiO_2$.

### 29. On the origin and prospecting of mica.

S. K. ROY *and* G. C. CHATTOPADHYAY, Dhanbad.

*Origin of Pegmatites*:—The authors are of opinion that the different types of pegmatites of Behar have originated from different fractions of the pegmatitic residual fluid separated from the granitic magma which gave rise to the 'dome-gneiss' of the region.

*Origin of Mica*:—Workable books of mica (muscovite) are found in pegmatites carrying plagioclase (albite-andesine) as the essential and major felspathic constituent, in contrast to the barren ones of which the felspathic constituent is overwhelmingly potash felspar.

With the data available from detailed field study of several hundred workable pegmatite veins of Kodarma area the authors suggest the following characteristics to be useful in prospecting for workable veins of pegmatite:—(1) Mica in workable quantities is to be found in a pegmatite vein which carries plagioclase as one of the major constituents of

the 'Reti', (2) such a pegmatite vein must possess a conspicuous core of massive quartz, (3) the pegmatites should carry such minerals as Tourmaline, Beryl, Apatite, etc., (4) in such a pegmatite vein the occurrence of workable muscovite varies from place to place but during development work the sure presence of muscovite in the proximity is revealed by the appearance of the transparent grey 'Kajra' quartz in the 'Reti', (5) 'Jogni' in Reti is a very favourable sign for the occurrence of workable muscovite lodes in the proximity.

## Petrology

### 30. On the origin and correlation of the cordierite hypersthene rocks and their associated basic granulites from Bidaloti (Mysore State).

B. RAMA RAO *and* T. P. KRISHNACHAR, Bangalore.

Drawing attention to the somewhat restricted occurrence of rock types which contain cordierite and hypersthene in association and to the diverse ways in which they might originate, the authors of the paper give a detailed account of the mineralogical, chemical and field characters of the cordierite hypersthene rocks and the basic granulites associated with them as exposed in the vicinity of Bidaloti (13° 31′ N.: 77° 17′ 30″ E.) in Mysore. From a careful investigation on the genesis of these rock types the authors conclude that the cordierite hypersthene rocks are clearly sedimentary in origin, but as a result of repeated metamorphism brought about by several igneous intrusions, have lost not only their original structural characters, but also have been considerably modified in their chemical composition. Due to an enrichment in magnesia and other constituents, the modified composition of the original sediments as reflected in their metamorphosed types, the present-day cordierite hypersthene rocks, correspond neither to that of argillitic sediments nor to that of basic igneous rocks and consequently the several diagnostic chemical criteria fail to give consistent clues to detect their original nature. However, the textural characters of these rocks, though ill preserved, give a sufficient indication to their original sedimentary character.

Of the basic granulites associated with them, the dark 'hornblende granulites' are found to be of igneous origin and intrusive into the sediments. The pyroxene granulites, the hypersthene-bearing types of which are comparable in mineral composition to the well-known charnockites, are found to have been formed from the contamination of the basic intrusive which gave rise to the 'hornblende granulites', with the original argillitic sediments, from a process akin to regenerative reaction. Both the hornblende granulite and the pyroxene granulite including the hypersthene-bearing types, are shown to be the modified phases of one and the same rock and therefore of the same age. They are both older than the granitic gneiss.

The effects of contamination in the formation of some of the abnormal rock types of the region have also been briefly touched upon in this paper.

### 31. Assimilation and the evolution of hypersthene-bearing rocks in Bastar State, Central Provinces.

P. K. GHOSH, Calcutta.

The assimilation of a basic diopsidic rock by a highly alkaline magma has produced the following stages in the evolution of hypersthene-bearing rocks :—

Stage I. Formation of hypersthene and garnet from diopside and anorthite molecules as follows :—

$$\underset{\text{Diopside}}{2\begin{bmatrix}CaO(MgFe)O.\\2SiO_2\end{bmatrix}}+\underset{\text{Anorthite}}{\begin{bmatrix}CaO.Al_2O_3.\\2SiO_2\end{bmatrix}}+\underset{\text{Silica}}{SiO_2}=\underset{\text{Garnet}}{\begin{bmatrix}3CaO.Al_2O_3.\\3SiO_2\end{bmatrix}}+\underset{\text{Hypersthene}}{2\begin{bmatrix}(MgFe)O.\\2SiO_2\end{bmatrix}}.$$

The resulting rock resembles a basic charnockite.

Stage II. Previously mentioned minerals + yellow hornblende passing marginally into a blue species (? more sodic variety) and plagioclase of medium basicity. The rock resembles an intermediate charnockite.

Stage III. A completely heterogenous type of rock, consisting of the basic constituents mentioned above embedded in a mesostasis of acid plagioclase, quartz, biotite and a little orthoclase. This stage represents a link in the chain of evolution of the final acid type (Stage IV).

Stage IV. Relative enrichment of potash, leading to the greater development of potash felspars and biotite than in the earlier type. Hypersthene is present in a smaller amount. The rock is similar in character to the acid charnockite.

It is suggested that possibly a similar mode of origin may be ascribed to other charnockite masses.

## 32. Further study of Mylliem granite, Khasi hills, Assam.

N. N. Chatterjee, Calcutta.

A preliminary account of the Mylliem granite was communicated to the 24th session of the Indian Science Congress (1937). The present paper deals with the structural features in some detail and the various processes of differentiation and assimilation that brought about the different varieties in the Mylliem granite. Of the structural features (i) weathering, (ii) joints, (iii) flow of felspar phenocrysts, (iv) veins, and (v) displacements have been discussed. There are typical tension fractures filled up in many cases by aplites, pegmatites and quartz veins. Sheet or horizontal jointing has developed fairly well. NE-SW joint is also present. The phenocrysts of felspar are found to flow in N-S with varying angles of pitch. The pitch is more northerly than in any other direction. There is also E-W and NE-SW flow. There are displacements in the granite as evidenced by the shifting of aplite and tourmaline veins and by fracturing and shifting of felspar phenocrysts and xenolith blocks. By the influence of hyperfusible constituents tourmaline-bearing granite, muscovite granite and early pegmatitic granite have been formed. Partly crystalline magma has subsequently been filter-pressed and late pegmatites and aplites have been formed. Assimilation process and formation of hybrid rocks have been discussed in the paper.

## 33. Permanganate oxidation of some of the Indian coals.

B. B. Niyogi, Dhanbad.

The present paper is a preliminary attempt to measure the reactivity of coal towards permanganate oxidation. Reactivity towards alkaline permanganate is measurable either by determining the change in solubility of the ulmin or by determining the amount of oxidizing agent used under standard conditions. Alkaline permanganate solution has been used, very recently, by Heathcoat and Francis to measure the rank of coal (Fuel, Vol. XI, No. 5, 1932, page 174).

In the present work sixteen samples of coal and one sample of lignite have been examined The results show that there is a relation between the Fuel Ratio and the ratio of *oxygen used* to the *solubility produced*. Lignite at one extreme shows great reactivity towards alkaline permanganate, indicating the maximum solubility. The solubility produced for

samples from the Barakar Series varies from 53% to 59·6% whereas for other samples the solubility varies from 78% to 84% (calculated on the pure coal substance). The Tertiary coals show a still higher solubility. This preliminary investigation has indicated what appears to be a criterion for rank identification. Vitrain bands selected from the samples may prove to be the most appropriate coal material to use in such investigations, because of its homogeneity and ease of acquisition and handling.

### 34. Micro-structure of some Indian fusains.

N. N. CHATTERJEE, Calcutta.

The specimens of fusain were obtained from (i) Talchir coalfield, (ii) Lalmatia, Hurra, and Jilbari coalfields, Rajmahal Hills, (iii) 13 and 14 seam, Jharia coalfield, (iv) Borodhemo and Borachak coal, Raniganj field, and (v) Tertiary coal from Salt Range. The Rajmahal Hills and Talchir field specimens are composed of abundant fusain patches. These specimens are found to contain several rows of bordered pits (uni-seriate, bi-seriate, poly-seriate, etc.). Measurements of tracheids were carefully made and several uni-seriate tracheids in the Gondwana specimens are found to be on an average $40\mu$ ($1\mu = \cdot 001$ mm.) across the pits (outer ring) and $10\mu$ in diameter. These characters suggest the presence of rich gymnospermous wood in the Gondwana fusain patches. Examination of a few polished blocks of Raniganj coal containing fusain patches by reflected light lends support to the above features. The Salt Range fusain on examination is found to contain only insignificant amount of tracheid with bordered pits. Several fragments of wood could however be found in transverse section showing water conducting cavities (vessels) of different sizes arranged in more or less regular manner. These are supposed to be fragments of angiospermous wood.

## Economic Geology

### 35. A new method of the quantitative estimation of gold in poor grade gold lodes.

S. K. ROY *and* K. K. DUTTA, Dhanbad.

The rusty brown, poor grade pyritic gold-quartz ores of Lowa (Manbhum) did not respond satisfactorily to the known methods of assaying gold given in literature, excepting to the dry assay. But use of dry assay is prevented by its prohibitive cost.

The method that has been devised entails a combination of well-known wet and dry procedures and has been found to be useful to accurately determine the presence of even 0·1 cwt. of gold in an assay ton of sample. Bromine and chlorine which dissolves gold easily were utilized as solvents. Previously roasted pyritic gold ore in contact with bromine water reacts as follows :—

$$2Au + 3Br_2 = 2AuBr_3$$

Bromine was then replaced by chlorine by the use of $KMnO_4$ and HCl, and the gold bromide was changed into chloride.

$$2AuBr_3 + 3Cl_2 = 2AuCl_3 + 3Br_2.$$

This gold chloride is then treated with Pb-acetate and zinc granules, evaporated and then scorified giving the bullion. The use of Br may be avoided by passing Cl gas only, through powdered ore moistened with water.

Precautions necessary in this method are that the bromine must be quite in excess of the ore, the $KMnO_4$ must be thoroughly dissolved in the solution Before HCl is added, evaporation should be carried out on a water bath in a lead basin and a large amount of borax should be used in scorification so that the slag may be very thin, fluid and glassy.

## 36. A study of the composition of the ashes of some Indian coals and lignites.

J. N. MAJUMDAR, Dhanbad.

The chemical composition of ashes of 49 samples of coals from Jharia, Raniganj, Talcher, Kargali (Bomaro field), Jainty (Jainty field), Singareni (Hyderabad), Pench Valley (Central Provinces), Assam, and lignites from Palana (Bikaner), and Kashmir have been studied. Distinction has been drawn between the compositions of ashes of Tertiary coals and those of other coals. Differences in percentages of ash, and of sulphur and phosphorus contents of the coals and lignites have been studied. In these respects striking differences have been observed. The most striking difference between the characters of ashes of Tertiary coals and those of other coals is the presence in ashes from Tertiary coals of very low percentage of silica, alumina and titanium oxide (absent in most of the cases) and high percentages of iron, lime, sulphur and alkalies suggesting their easy fusibility. There are striking differences in the colour of ashes from different coals and lignites. Aqueous solutions of coals of Tertiary formation have been found to differ very considerably from those of other coals.

## 37. Auriferous alluvium of the Gurma *nadi*, Manbhum.

B. C. ROY *and* A. K. DEY, Calcutta.

The paper embodies the results of field and laboratory investigations of some auriferous alluvials collected from the bed of the Gurma *nadi*, near Dhadka, in Manbhum district. Samples were collected from various localities and concentrated by panning. After a preliminary elimination of the magnetic portion of the concentrate, the non-magnetic portion was treated with Thoulet (Sp.Gr. 2·8) solution. The heavy residue was further fractionated by Rohrbach (Sp. Gr. 3·35) solution. The mineral assemblage is suggestive of the presence of auriferous tourmaline-quartz veins and a metamorphic suite of rocks in the drainage area. It appears that the gold bearing veins represent a pneumatolytic-hydrothermal facies—probably a rest solution of differentiation of a granite magma. A detailed systematic examination of the detritals is required before any idea of the gold concentration could be ascertained.

## 38. Study of some varieties of Indian asbestos.

M. P. NETARWALA *and* H. S. DALAL, Benares.

The authors in this paper mention the occurrence of asbestos in different localities of India. Some of the varieties have been analyzed and their resistance to concentrated hydrochloric and sulphuric acids have been determined. From the study, the authors conclude that the asbestos of Seraikelā State, Bihar and Orissa and of Dungarpur State, Rajputana is of the amphibole variety and it could be used for chemical filtration in the manufactures of washers and rings, etc. as a lagging material. The chrysotile of Kurrana, Punjab and of Basi, Rajputana could be spun into cloth, twine and rope and then put to various uses. The asbestos of Kuruntia, Ajmer Merwara could be utilized for making asbestos cement.

## 39. Dykes in the Deccan trap and their influence on underground water.

G. G. NARKE, Poona.

In this paper the author has described the formation of a sand basin in the bed of the Karha river between Morgaon and Karhati villages in the Poona District due to the presence of a hard compact dyke at Karhati

and the sinking of wells in the neighbourhood, to bring under cultivation about 150 acres of waste *forest land*.

## 40. The uppermost ferruginous flow in the Deccan trap and its utility as a water bearing formation on top of the hill forts of the Western Ghats.

G. G. NARKE, Poona.

The author has described the occurrence of water at about 2,400 feet above the surrounding plains on top of Singhgarh Fort, 14 miles distant from Poona and other places in the Deccan.

# SECTION OF GEOGRAPHY AND GEODESY

*President* :—A. M. HERON, D.Sc., F.G.S., F.R.G.S., F.R.S.E., F.N.I., F.R.A.S.B.

## 1. Types of movements of people in the Cauvery delta.

S. MUTHUKRISHNA AYYAR, Madras.

1. A general survey of motives for migration in different ages to serve as a sort of back-ground for the investigation.
2. Classification of the types of movements in the selected area under three main heads, *viz.*, movements (*a*) into, (*b*) within and (*c*) from the region.
3. The geographical and other causes of these movements—past and present.

*Early attractions for immigration*—

1. Natural irrigation facilities.
2. Canals and anicuts.
3. Rainfall in the growing season (rice plant).
4. Annual silt carried by the river.
5. Stable and benevolent government.
6. (Protection against inroads.)
7 Patronage of arts, crafts and learning.
8. State and private charities.
9. Flourishing ports, etc.

*Causes of the present day outward flow of population*—

1. Maximum use of resources (irrigational).
2. Inability to find food for the growing population.
3. Imprudence, easy-going life and high standard of living.
4. The British rule, English education and advance in communications, wide outlook and high ambition.
5. Soil deterioration.
6. Small holdings.
7. Enforced idleness for six months a year.
8. Difficulty in the change of crops, etc.

4. Comparison with other deltas, Malabar and Tinnevelly.
5. The social and the economic effects.

(*a*) Deserted villages.
(*b*) Poverty, disease and premature death.
(*c*) Growth of urban population.
(*d*) Low fertility, slow increase of population.
(*e*) Luxuries, litigation and absentee landlords, etc.

6. A typical delta village (surveyed).
7. Remedial measures for counteracting the adverse effects,—how to send people back to the villages.

## 2. A geographical study of the Ranchi plateau.

S. C. CHATTERJEE, Ranchi.

In this paper the geological structure of the plateau is studied in relation to the morphology, followed by a study of its climate, soil, vegetation, land utilization, and distribution of population.

## 3. The shifting of population-centres in Bengal.

S. P. CHATTERJEE *and* S. K. BOSE, Calcutta.

Geographical factors leading to the development of a number of towns in modern times at the expense of old towns have been studied. This migration of population has resulted in marked changes in life and activities of the people.

## 4. Geographical interpretation of the distribution of population in two typical districts in India.

S. P. CHATTERJEE *and* A. GANGULI, Calcutta.

Two typical districts—Nadia and Tinnevelly—are selected and geographical factors determining density of population in different parts of the districts have been studied. Anomaly in the distribution of population in some parts of the districts has been traced to the decline of industry and failure to respond to the changed environment.

## 5. Natural regions in India.

S. P. CHATTERJEE, Calcutta.

The classification is based on the character of the forest flora, surface relief and climate. Man's adjustment to the physical environment has been shown in each of the natural regions.

## 6. Place names in Tamil country.

C. M. RAMACHANDRA CHETTIAR, Coimbatore.

A study of place names is interesting and instructive in every aspect of human life. History, geography and other human sciences find a large treasure in the current names of places when analyzed and studied with proper perspective.

1. *Natural divisions*: A particular name of a division always carried a particular set of ideas regarding the people, flora, fauna, vocations, customs and manners. The conventional divisions according to the Tamil poets were :—

1. Hilly region—Kurinji.
2. Pastoral tracts—Mullai.
3. River valleys—Marudam.
4. Desert country—Palai.
5. Sea-side region—Neithal.

When analyzed the prefix of each name denotes the origin and the suffix the nature of the country. The place names testify the above classification.

2. *Inhabitants*: The infusion of Kanarese and Telugus into the pure Tamil country and their influence in all human affairs. This is indicated by the ratio of Kanarese and Telugu suffixes with the Tamilian in place names.

3. *Occupation*: Suffixes are also found according to the occupations of the people. The predominant occupations were agriculture, handicrafts, trade and commerce, pasture, forestry, etc.

4. *Administration*: Villages and tracts were divided for purpose of administration and suitable prefixes were adopted for zamin, inam, agraharam zagir or ryotwari.

5. *Historical*: Prefixes and suffixes relate to innumerable historical facts, e.g. origin of places and other historical incidents.

6. *Other Aspects*: A good number of place names have religious, mythical, geographical and geological origin. Curiously even geological origins are found as Kanjamalai (Gold), etc. Some are of pure Tamil origin and some are of Sanskrit origin which denote clear cleavage in the infusion of civilizations.

7. *Local Tradition and Dialects*: Certain names are peculiar to certain districts and even dialects are represented. Archaic names sometimes persist.

## 7. Post-Mesozoic movements in Chhota Nagpur.

J. A. DUNN, Calcutta.

An early Tertiary peneplain, now represented by the Neturhat plateau and other residuals, was lifted in early Tertiary times about 1,000 feet in the centre of Chhota Nagpur, with a tilt to the north-east towards the Rajmahal hills.

Between the middle and late Tertiary there was a further uplift of perhaps 1,000 foot, reaching a maximum on the Ranchi plateau and its dissected extension to the south. This uplift resulted in a tilt to the north and north-east from the Hazaribagh plateau. Along the Son river the northern edge of the uplift was abrupt, as also along the eastern edge of the Ranchi plateau.

In South-East Chhota Nagpur (South Dhalbhum) further uplift, amounting to some 300 feet, took place after an interval which had permitted the development of quite a well-defined peneplain—this upwarp was rather abrupt along the Subarnarekha river.

From the south-eastern part of this region extending to the coast, a general rise, amounting to a maximum of 400 feet, has continued down to the present day.

The movement has, therefore, been cumulative in central and south Chhota Nagpur; there has been little or no apparent differential movement in the region of the Rajmahal hills, whereas further north the Gangetic plain has been a region of apparently persistent depression.

## 8. The great divide.

C. B. FAWCETT, London.

'The Great Divide' is the belt of deserts across the old world, from the Sahara north-eastward to the tundra of East Siberia. Because of its climates, and its geographical position, this zone has been the dividing area between the agricultural regions, with their dense sedentary populations and developed civilizations.

The paper attempts a review of the characteristic features of this 'zone of separation' and of its relative importance in the past and to-day.

## 9. Geography and the scientific movement.

H. J. FLEURE, Manchester.

Darwin's view of life, as in process of continued mutual reaction with environment, pressed forward study of evolution of relations of human groups to environments. Results show that group life is basic fact and that self-conscious individuality appears to varying extents in various stages of groups evolution. Geography on the human side may, therefore, be called Human Ecology or Applied Darwinism.

## 10. The origin of the great river-gorges of the Himalayas as evidenced by the distribution of fishes.

S. L. HORA, Calcutta.

A summary of views regarding the origin of the great river-gorges of the Himalayas is given. It is pointed out that the fish faunas on the northern and the southern slopes of the Himalayas are quite distinct, and that an explanation of this fact is to be found in the origin and the present form of the Himalayas. The evolution of the present-day drainage pattern of the southern face of the Himalayas is traced from the evidence afforded by the distribution of fishes, and it is concluded that the early drainage of the Himalayas was from east to west along both the faces, and that it underwent considerable changes due to differential orogenic movements in the region west of the Tista drainage system and in the Potwar Plateau. The distinctness of the northern and the southern fish faunas of the Himalayas favours the view that at an early age the Himalayas had ordinary consequent drainage, the rivers flowing north and south of the crest. The distribution of fishes along the southern face indicates that the rise of the Himalayas occurred in sharp, sometimes localized, earth-movements, so that the fishes always remained in the valleys and were unable to colonize the precipitous higher reaches. A reference is also made to the influence of the monsoons on the southern face, and to the process of river-captures that probably played a great part in the distribution of fishes from the east to the west. From the evidence presented, it is concluded that the south-flowing rivers, through vigorous erosion, captured the rivers on the Tibetan side of the range.

## 11. Environmental and cultural changes of pre-historic Man near Madras.

V. D. KRISHNASWAMI, Madras.

The author, after selecting a promising area in the Kortalayar valley, joined the Yale-Cambridge North Indian Expedition.

Their work over, T. T. Paterson and H. J. Drummond came over to his area. Four terraces were then traced and mapped out, and the connected lithic industries investigated at Cambridge along with the North Indian Collections.

The conclusions based upon limited field work were :—

1. A boulder conglomerate bed, resting on Jurassic shales, underlies the laterite peneplain—$T_0$ ;
2. $T_1$ cuts into the laterite peneplain ;
3. $T_2$ (well developed at Attirampakkam) is an Acheulean site ;
4. $T_4$ (seen best near Erumaivettipalaiam) is alluvial.

There appear to have been two major pluvial periods separated by a dry phase and then a minor wet phase—corroborating the results of Burkitt and Cammiade in the Upper Kistna.

A progressive evolution in technique and typology of the industries is disclosed and the Clacton type invariably precedes the Levallois. The maximum development here corresponds in the opinion of L'abbe Breuil to the Combe Capelle stage. Cultural stages present marked similarity to the African and Burkitt has in a brilliant paper insisted on the importance of investigating its causes.

The flake industry appears to have been as well developed in South India as in Java, though Callenfels and Koenigswald have thought otherwise.

The results make it probable that the Kistna and Godavari valleys would yield quite similar ones.

## 12. Population and its distribution in Kerala.

GEORGE KURIYAN, Madras.

Kerala is one of the most densely peopled parts of the world, with an average density of 660·9 persons per square mile. The region is essentially agricultural. This high density could only be accounted for by the exceptional productivity of the region. Rainfall seems to have very little influence on density. It depends on the proportion which the land cultivated with food and money crops bears to the gross cultivated area. Every person has on the average about 0·4 acres of cultivated land, while every person supported by agriculture has 0·9 acres of cultivated land, both of which are extremely low figures. The possibilities of extending the acreage under cultivation are not great. The average yield is very low and scientific methods could not be easily adopted owing to the small holdings. The distribution of population of Kerala is different from the adjoining Tamil Nad; the settlements are dispersed; there is no village in the strict sense of the term; but its town is a real urban agglomeration. The average rate of growth of population during the last census decade within this region has also been phenomenal; Travancore, due to the better utilization of its highlands, has registered the greatest growth.

## 13. Urban centres in Kerala.

GEORGE KURIYAN, Madras.

In any country it would be difficult to condense into a formula the attributes of a town and in Kerala, where the village represents in essence an extent of country throughout which isolated houses are dotted, certainly no hard and fast line exists. The most important aspect of a town should be the character of the population and the relative density of the dwellings. An urban area is one where the majority of the population follow non-agricultural occupations. On the functional basis, it is possible to classify the towns into (1) Capitals, (2) Industrial towns, (3) Commercial towns, (4) Market towns, (5) Religious towns, (6) Agricultural and distributive towns. There are 30 urban centres in Kerala. More than 75% of the total urban population live in the larger urban centres with a population in excess of 20,000. The total urban population forms only 8·5% of the total population and this indicates that Kerala is far from being urban. The Mahomedan element in the towns is greater than in the rural parts while the contrary is true of the Hindus. This is due to the difference in occupation of these communities. In Kerala the towns are mostly confined to the coastal lowlands—the area of easier communications—they have invariably arisen at the crossings of the lagoons and the backwaters.

## 14. The Tambaraparni basin.

S. MUTHUKRISHNAN, Madras.

This paper is an attempt at showing how the Tambaraparni basin adds a splash of green to the naturally dull brown colour of the vegetation map of Tinnevelly district, and to contrast the effect on environment in the basin with that outside.

The annual rainfall in Tinnevelly district is the lowest of all those of the east coast districts, and the effect of this on the geography of the district is one of difficult irrigation and poor produce. But thanks to the salutary effect of the summer monsoon coming through the Ariankavu Pass, and the effect of the monsoon winds giving rain just on the lee-side of the Ghats, this ribbon of the Tambaraparni is made possible in an area which would otherwise be scrub-jungle.

This river basin is in all ways different from the rest of the district. Here water is conserved systematically, and irrigation is used to the best advantage. The fertility of the basin and its three crops in a year contrast with the cotton crop of the north, and the palmyras and single crop of the south. The greatest number of the bigger towns in the district are in this basin, barring only a few outside it, which have grown due to commercial or nodal importance.

The individuality of this interesting region has been brought out in the paper.

## 15. The technique of regional geography.

A. G. OGILVIE, Edinburgh.

The lack of detailed regional studies in India and the advantages that would accrue from them are pointed out. The large body of information available for such synthetic studies is indicated, its character examined, and its proper use by geographers suggested. The more serious deficiencies in knowledge are discussed, first in regard to various aspects of the physical environment, and secondly in respect of the population, its distribution and its activities. In each category new field observations and new map compilations are required, demanding the use of methods so far scarcely applied to Indian regions. Special attention is directed to the possibility of constructing adequate maps of population density. The employment of diagrams of types hitherto little used is recommended. Means are suggested for establishing and maintaining contacts between geographers in Europe and India.

## 16. Settlements in the lower Indus basin (Sind).

MANECK B. PITHAWALLA, Karachi.

The lower Indus basin (Sind) has afforded facilities for some of the earliest human settlements in India, although it is an unstable land; with an unstable population depending chiefly upon unstable water supply. It is a land also of changing river courses, changing lakes, changing coastline, an advancing delta, intensely weathering Tertiary rocks and accumulating sand. Even the sand-hills of the desert are changeful as the winds blow during the year. The region, again, is within the danger zone of Northern India and is unique in its numerous hot springs. There is a possibility of changing climate as well and of gradually rising level and desiccation.

An antechamber for the whole country, with such a classical river as the Indus, Sind has not a single classical town left, except Sehvan (Sindomana), and that too in a partially decaying state. Floods were the greatest menace to human habitations, Mohenjo Daro itself being thrice abandoned on this account. Again and again people tried to resettle on mounds higher up, the river left its channels, and a whole river—the Hakra—dried up in the Pat-Thar section. Thus towns and villages often vanished.

The paper has been based on a detailed study of

I. *Geomorphology:* (*a*) Aggradation by the river and æolean agencies; (*b*) Erosion by external agencies; (*c*) Flood menaces; (*d*) Tectonic changes; (*e*) Growth of the delta.

II. *Hydrographical changes:* (*a*) Unstable water supply and water table; (*b*) Unstable drainage, river piracy, etc.; (*c*) Unstable lakes.

III. *Other changes* in human settlements due to political causes, etc.

Thus some 20 old sites have been located by the author in a map of Sind and their history given. The Sukkur Barrage with its perennial water supply and its final redistribution of population may mean more or less stable settlements in days to come.

## 17. Main house types in South India.

K. M. SUBRAMANIAM, Madras.

An attempt is made here to bring out the influence of environment in the choice of materials and the plan of construction of typical houses in the four main regions of South India.

*The Ceded Districts type* of stone-walled, flat-roofed houses, without a central courtyard, has developed in a region of scanty rainfall and extreme temperatures. The paucity of clay suitable for making bricks and tiles and the abundance of Cuddapah slabs explain the free use of the latter in various ways.

*The Malabar house*, built on high ground with steep gables, storage loft and a liberal use of wood, shows the adaptation to environment in a region of heavy rainfall and abundant forests.

*In the Northern Circars* are to be seen mud-and-brick houses with tiled or thatched roofs. Of the two types prevalent here, one has an open courtyard. Jungle wood and bamboo are largely used. The gable denotes a region of fair rainfall.

*In the Tamilnad*, the typical house has a central courtyard for free ventilation and sunshine, and a gently sloping gable, which show the influences of moderate rainfall and a fairly equable climate. The large use of bricks and tiles indicates the availability of suitable earth.

A closer study reveals minor local variations of the four main types.

## 18. Some aspects of the growth of greater Madras.

N. SUBRAHMANYAM, Madras.

The suburbs of Madras have grown ribbon-like along roads and railways by the overflow of the city population into the pre-existing villages along those routes. This development has taken place more fully in the south-west than in other directions, due to a higher and better-drained surface.

Besides the residential areas, large institutions—educational, recreational and governmental—have been established in this south-western part of Greater Madras, as space is limited and site values high within the city.

While shops and markets have grown up in the several suburban areas, the city in its turn gets its supply, especially of perishable articles, from the former areas and the surrounding rural parts.

Quick and cheap transport in the shape of suburban trains and buses ply frequently, making suburban life possible. Their number and frequency reflect the relative importance and popularity of the several suburban areas.

Recently, the vacant areas in the south-western parts of the city are being built over, due to a desire to enjoy the better conveniences and amenities of civic life ; and Thyagarajanagar, one of such recent extensions within the city, stands unique as the result of deliberate planning.

A plea is put in for the creation of a local authority to plan and co-ordinate the development of the several suburban areas without mutual competition, taking a long view.

## 19. The rivers of the Palar basin.

B. M. THIRUNARANAN, Madras.

The Palar is one of the three largest rivers of the Tamil region, and drains an area second only to the Cauveri. The lower portion of its valley is drained by several small rivers which enter the sea by separate mouths, even though they have very little flow of water. These small rivers have valleys too wide and large for their present volume of flow.

Bruce Foote has pointed out, in connection with the distribution of alluvium in this area, that several changes have taken place in the courses of these rivers, including the Palar, and that they have probably occurred in historic times. The Kalingattupparani, written by Jayamkondan, states that the Palar flowed to the north of Cojeevaram at that time (1070 to 1119 A.D.) and thus helps us to fix the date of the change in the course of the Palar. Bruce Foote has further suggested that these changes may have been caused by human agency. The serious floods which occur in the Palar as a result of the breaching of tanks along its course appear to be sufficient to have caused these changes in the past.

## 20. The geographical limits of the Tamil region.

B. M. THIRUNARANAN, Madras.

This paper attempts to define as precisely as possible with the aid of available topographic maps the geographical limits of the Tamil region, which forms a fairly well-defined natural unit. Its boundaries have been defined with reference to its physiographic characteristics, its geological structure and its plant cover, and the interrelationships between them. The limits thus determined differ from the limits indicated by climatic conditions, but show close agreement with the distribution of cultivation, of habitations, and of communications, as well as with the limits of the cultural unit, as shown by the distribution of the Tamil language and the traditional limits ascribed to the Tamil region.

## 21. The geography of disease.

(Miss) M. W. F. WADDINGTON, Madras.

As Geography is the study of man in his environment, it is necessary to study the abnormal as well as the normal condition of man as a physical being. Of the factors of environment, climate is the chief in this connection. Its action may be direct, as when the conditions of air temperature, moisture and movement affect favourably or otherwise man's body: or indirect, as in the influence of climate on the crops, and other sources of food supply, and on insect life, which play such an important part in the study of disease. Effect chiefly seen in study of Tropical Medicine, but factors equally important in other climatic areas. Firstly, diseases due to heat or extreme cold; secondly, those showing the effect of altitude, and light; thirdly, those due to disturbances of diet; fourthly, the control of disease by water supply. Then comes the group of diseases of 'animal origin', parasites, flies, etc., or those contracted directly. The effect of modern developments of transport on distribution of disease. Study of important tropical and other diseases; their control, and their effect, apart from mortality. The universality of certain diseases. The economic importance of disease necessitates its inclusion in the study of Geography.

# SECTION OF BOTANY

*President* :—B. SAHNI, Sc.D., F.R.S.

## Cryptogams

(*Chairman* : PROF. M. O. P. IYENGAR.)

### 1. The nature of the subterranean algal soil-flora.

F. E. FRITSCH, London.

Many diverse algæ can be obtained from soil-samples taken at considerable depths below the surface and there are records of the occurrence of algæ down to a metre or more. In Europe this subterranean flora practically always includes common surface forms, like species of *Hormidium* and *Chlorococcum*, although others like *Prasiola* and *Zygogonium* which do not readily fragment have never been recorded below the surface.

A number of soil-algæ can readily be grown in artificial cultures in the presence of carbohydrates (glucose, etc.) and other organic media. In many instances, too, it has been found that good growth is made, even in darkness. It has, therefore, been assumed that the algæ buried in the soil lead a saprophytic existence and there exhibit active growth and multiplication. It is very doubtful, however, whether this assumption is warranted. The organic materials present in the soil are certainly in great part different from those utilized in artificial cultures. Moreover, direct attempts to grow soil-algæ in sterilized soil in darkness (Petersen), have afforded no evidence that they can multiply under the circumstances.

We are indebted to Bristol for a statistical study of the numbers of algæ occurring at different depths in a soil, and this investigation showed that, whilst there was decrease in numbers immediately below the surface, there was marked increase at 4 inches. That minute particles like algal cells are readily washed downwards into the soil to considerable depths has been shown experimentally, and the abundance at the 4 in. depth is probably to be ascribed to the occurrence of some physical barrier.

The evidence indicates that the subterranean flora comprises forms which are passively washed downwards from the surface during rain; this is indicated by the almost invariable occurrence of common surface-forms in the deeper layers. The apparently distinctive subterranean types have, however, to be accounted for. Most of the work on soil-algæ in recent years has centred round their depth-distribution and little has been done on the surface-flora. The investigations of Petersen in Iceland and elsewhere have shown, however, that a far greater diversity of forms are to be found at the surface than has hitherto been supposed, and more extensive investigations would probably appreciably increase the number. Many of the distinctive subterranean forms that have not hitherto been found elsewhere belong to the Xanthophyceæ (Heterokontæ) and, since these forms are known often to be light-shy, it is quite probable that they do not inhabit the actual surface, but occur a short distance beneath it where light, though of lower intensity, still penetrates. It is not unlikely that investigation of the soil-layers that still receive light would demonstrate a microstratification of the algal flora and that the apparently distinctive subterranean forms would be found as inhabitants of the layers just beneath the surface.

It will be familiar that the ordinary means of dispersal of freshwater algæ from place to place is effected by wind-borne resting spores. Large numbers of these must fail to reach other bodies of water and will fall on the soil-surface, there either to perish or to be washed downwards by rain. This, in my opinion, accounts adequately for the very diverse casual element in the subterranean flora.

It is, therefore, probable that the true algal flora of the soil is to be found in the surface layers reached by light, and that it is here that it fulfills its important biological rôle. When once washed into the part of the soil that is in darkness, some individuals may persist as spores or perhaps even as vegetative cells, but it is improbable that these exhibit any vegetative activity there. From the economic point of view, the importance of algæ in the soil rests on their presence at the surface and it is here that their distribution and conditions of existence should be studied.

## 2. The life-cycle of the Ectocarpales.

F. E. Fritsch, London.

It is now clearly established that the normal life-cycle in *Ectocarpus* and its immediate allies involves an isomorphic alternation between practically identical diploid and haploid phases, each capable of independent propagation by swarmers from plurilocular sporangia. In the more advanced members of the group Ectocarpales, taken in the widest sense, we find a marked elaboration of the plant-body which may attain to considerable complexity. Only in a few (e.g., *Nemoderma*, *Lithoderma*), however, does this elaboration appear to have affected both phases alike so that the alternation remains isomorphic. In the vast majority of the higher Ectocarpales it is the diploid sporophytic stage alone that has been elaborated, whilst the haploid phase remains a simple ectocarpoid filament, i.e. the life-cycle presents a heteromorphic alternation. It is very significant that the early stages of the diploid phase in these forms always appear as heterotrichous ectocarpoid plants, from whose erect branches the mature diploid phase is progressively elaborated. Under conditions of culture, and probably also at certain times of the year in nature, the juvenile diploid phases may persist for considerable periods (Sauvageau's 'plethysmothalli' in part), propagating by means of diploid swarmers from plurilocular sporangia. At other times the gametophytic stages may remain asexual and propagate by means of haploid swarmers which represent apogamously developing gametes.

## 3. A note on two interesting South Indian marine algæ; *Pseudovalonia Forbesii* (Harv.) Iyengar comb. nov. and *Pseudobryopsis pambanensis* sp. nov.

M. O. P. Iyengar, Madras.

Living material of both these algæ was brought from Pamban and grown at Madras in the laboratory and the several stages of their life-history were studied in some detail.

*Pseudovalonia Forbesii* (Harv.) Iyengar comb. nov.

(*Valonia Forbesii* Harv.)

This alga was until now placed in the genus *Valonia* but a study of its structure and development shows that it does not belong to this genus. A new genus *Pseudovalonia* is created for the alga. The reasons for separating it from *Valonia* are discussed in detail.

Numerous 4-ciliated motile spores are formed in the vesicle and escape through a number of round apertures formed in its wall and, after swarming for some time, finally settle down and grow into new

plants. No case of sexual fusion was observed. The occurrence of 4-ciliated swarmers in this alga is interesting, since usually only biciliated swarmers are formed in the Valoniaceæ. The only previous record of 4-ciliated swarmers is by Kuckuck in *Valonia macrophysa* Kutz.

Under unfavourable conditions, plenty of cysts are formed inside the vesicle. These cysts grow into new plants, when conditions become more favourable again.

*Pseudobryopsis pambanensis*, sp. nov.

The structure of the thallus and the formation of the swarm-spores in a new species of *Pseudobryopsis* from Pamban are described in detail. When the spores are fully differentiated inside the sporangium, they are shot out in a mass through an apical rupture into the surrounding water and swim away as biciliated swarmers. No conjugation of these motile spores was observed nor their germination into new plants. This kind of sudden and forcible discharge of the contents of the sporangium shows a certain amount of resemblance to what takes place in the fungus, *Pilobolus*. Such a phenomenon does not appear to have been recorded in any alga so far.

The ruptured apex of the sporangium gets closed up by the formation of a new wall-piece. The same sporangium can, after a few days, again form a mass of spores at the apex as before and discharge them once more. This process may be repeated for each sporangium several times.

## 4. A note on a *Physocytium* from South India.

M. O. P. Iyengar, Madras.

*Physocytium confervicolum* Borzi was first described by Borzi from Italy in the year 1883, but does not appear to have been recorded again by anybody so far. The author collected this alga two years ago in a stream at Vaiyampatti near Trichinopoly in South India. The structure and life-history of the South Indian form are described in detail and the author's observations confirm those of Borzi.

This genus was variously placed by the previous workers in different families. Lemmermann, West and Printz include it in the Chlorangieæ. Oltmanns places it in the Chlorodendraceæ. Fritsch has recently suggested its inclusion in the Chlamydomonadaceæ. The study of the life-history of the alga shows numerous points of resemblance to *Chlamydomonas* and the author therefore thinks that there is every reason for removing it from the Chlorangieæ and placing it in the Chlamydomonadaceæ as suggested by Fritsch.

The peculiar feature of the alga is the retention of the motile daughter-cells for a very long time inside the globular mucilaginous envelope formed by the gelatinization of the mother-cell-wall which again remains attached to the substratum by the two original elongated ciliary stalks. This motile stage of the daughter-individuals inside the mother-wall forms the dominant vegetative phase of the alga. It is interesting to note that this type of motile condition of ciliated daughter-individuals inside the gelatinous mother-envelope for a very long time as the dominant vegetative condition of the alga has been recorded in a few other Volvocaceæ also. A very brief account of these is given in the paper.

## 5. Aposporous prothalli in *Osmunda javanica* Bl.

P. C. Sarbadhikari, Colombo.

1. Aposporous growth of the prothalli originates either from the surface, or more frequently from the edge of the frond.

2. The majority of the prothalli are regular in shape, but irregular ones are by no means uncommon.

3. The regular prothalli are much more heart-shaped, except that they have no well-developed cushion.
4. The appearance of the embryo is heralded by the formation of a very much localized hypertrophy situated just behind the growing-point.
5. The embryo arises as a direct vegetative outgrowth from the prothallus, and, when very young, consists of a mass of cells in which the apical cells of the cotyledon, stem and root, are recognizable.
6. There is no reduction of the chromosomes on passing from the sporophyte to the gametophyte.
7. The evidence afforded by the material on which the study of these prothalli has been based leads to the conclusion that the whole process is to be regarded as a kind of irregular fertilization. The doubling of the chromosomes receives an explanation strictly analogous to that afforded by the normal fusion of the oosphere and spermatozoid. But instead of one cell only serving as the starting point for the new generation, a number of such units loosely co-operate to produce it.

## 6. Contributions to our knowledge of Indian marine algæ. I. On some green algæ from Karachi.

P. ANAND, Lahore.

The total number of species described so far is 18, some of which are new records for the Indian coast. They include 3 new species (*Cladophora kemariensis*, *C. Fritschi*, *Chaetomorpha prostrata*) and one new variety (*Caulerpa racemosa* var. *intermediata*).

*Cladophora kemariensis*: Plants forming loose tufts, 12–35 cm. high, without any branches in the basal portion, dark olive-green, flaccid, cells of the main filaments 220–270μ in diameter, more than 10 diameters long, branching alternate or opposite, in certain terminal tufts di-polychotomous, ultimate ramuli alternate, with or without one or more cells in between the ramuli and strongly lamellate cell walls, cells of the ramuli 100–150μ in diameter, 2–4 times as long.

*C. Fritschi*: Plants 9–15 cm. high, yellow-green in colour, soft, tufts of ramuli in which the branching is di-polychotomous, cells of the main filaments 200–250μ in diameter, 6–8 times as long, cells of the ramuli 50–80μ in diameter, 4-5 times as long.

*Chaetomorpha prostrata*: Plants forming compact mat by intertwining of the filaments. Filaments declined, coiled and contorted, attached by means of rhizoids to the soil and to one another. Rhizoids usually one, rarely two from each cell, binding lot of mud.

*Caulerpa racemosa* var. *intermediata*: This variety combines the characters of a number of different forms. The same assimilator may bear ramuli with convex, concave or disc shaped apices and on the same stolon some assimilators may bear uniformly thickened ramuli. Some assimilators may also bear a few typical peltate ramuli like those of *C. peltata*.

## 7. Observations on the morphology, cytology, and development of a South Indian Pithophora.

K. R. RAMANATHAN, Madras.

1. Three forms of *Pithophora* (probably belonging to *P. polymorpha* Wittr.) were investigated in detail with a view to study their structure and life-history. All the three forms showed a differentiation into a distinct cauloidal and a rhizoidal system. Helicoids were observed frequently in all the three forms and showed several variations. In addition to the usual unseptate helicoids described by various authors, septate helicoids were also often observed. Such septate helicoids do not appear to have been recorded so far in *Pithophora*. These helicoids, whether

septate or unseptate, were often observed to proliferate new filaments from some of their branched ends. Proliferations from helicoids have not been previously known in *Pithophora.*

2. A cytological study of the vegetative cell and of the resting spore was made with the help of microtome preparations. The nuclear division is mitotic and quite similar to that of *Cladophora.* The number of chromosomes is probably 30–36. The spindle is intranuclear. The nucleolus reacts negatively to Feulgen's nuclear reaction. In addition to normal nuclei, some abnormal nuclei nearly twice the size of the ordinary ones were observed. The evidence available suggests that these large nuclei are probably derived by the fusion of two ordinary nuclei. Such large nuclei were found inside the spores also.

3. The development of the spore was followed in detail. The release of the ripe spores does not take place by the more decay of the thallus, as is usually believed. The subsporal cells form a ring-like swelling on either side of the ripe spore through the activity of their sparse protoplasmic contents. Soon a break of the filament takes place along the circumference of each of these two ring-like swellings and liberates the spore from the filament.

4. The germination of the spore was followed in detail and some new observations are recorded.

## 8. The prothallus of *Equisetum debile*, Roxb., var. *pashan*, Poona.

T. S. MAHABALE, Ahmedabad.

The prothallus of this local variety of *Equisetum* is a small, circular, button-shaped body, red, brown or green in colour, measuring about 1 to 2·5 cms. in diameter and, 0·2 to 0·3 cm. in height, including the lobes.

The body of the prothallus is divisible into three parts : (1) an upper part, bearing erect leafy lobes, marginal meristem and reproductive organs ; (2) a massive cushion in the middle, made up of four to seven layers of thin walled cells ; and (3) a lower part with numerous rhizoids. The prothalli are monoecious, and agree in this respect with the prothalli of *E. lævigatum*, *E. kansanum*, and *E. debile* proper, but not with those described by Buchtien, Goebel, Hofmeister, and Phatak.

The paper further discusses the symmetry of the prothallus in *Equisetum.* The prothallus is radially built in Psilotales and Lycopodiales. The gametophyte of *Equisetum,* as found in nature, has erect lobes, reproductive organs and embryos all round the thallus, and a cushion in the middle. It is difficult to consider such a structure as dorsiventral. A comparison has been further made with the prothallus of *Lycopodium cernuum* and it has been suggested that flattening out of the prothallus in *Equisetum* is due to condensation of the middle region corresponding to the shaft in *L. cernuum.* This, however, does not appear to affect its symmetry which may, therefore, be considered as radial.

# Phanerogams and Taxonomy

(*Chairman* : PROF. S. P. AGHARKAR.)

## 9. The origin of different forms of ovules in the angiosperms.

A. C. JOSHI, Benares.

Evidence is presented from the development of the carpels and ovules in a number of families of modern flowering plants and from the systematic

distribution of the orthotropous ovules to show that the different forms of the ovules have originated as a result of various mechanical forces exerted on the ovules during development. The subjection of an ovule to pressure from all sides during its development has resulted in the origin of the anatropous ovule. Absence of pressure from one side has resulted in the appearance of the amphitropous ovules. The campylotropous ovules have originated either from the anatropous or amphitropous ovules, because they pass through these stages during their development and the ovules in some cases are ana- or amphi-campylotropous. They represent the most advanced form of the ovule, and the factors responsible for their origin from anatropous or amphitropous ovules are either extra external pressure exerted by the growth of the placenta and funicle or internal pressure caused by the stretching and curving of the embryo-sac. Such a view of origin of the different forms of ovules explains the occurrence of transitional forms in many plants, the variations in the orientation of the ovules in a carpel or in the carpels of closely related species and genera, and the absence in many cases of any relation between the direction of the ovules and the position of the style and stigma. The anatropous ovule is most common now because with the porogamous method of fertilization it is the most suitable form of the ovule. It limits to the minimum the distance through which the pollen-tube has to travel in an empty space.

## 10. Observations on the flora of Bhutan.

K. P. BISWAS, Calcutta.

The territory of Bhutan forms an integral part of the botanical province known as the Eastern Himalayan Province. In discussing the vegetation of Bhutan one cannot separate the adjacent plant communities of Sikkim on the west and the vegetation of the montane zone of Assam. Plant hunting in the Sikkim area dates from a very early period, and systematic collection of the interesting flora of this region was started by J. D. Hooker in 1848. Hooker's account and his treatment of the plant communities will supply valuable data upon which any conclusion on the vegetation of this part of the country can be based. Although much of the primeval nature of the forest flora and political demarcation of territories have undergone changes since.

The present boundary of Bhutan does not include Kalimpong, which was annexed after the detention of Hooker in 1849. Since 1866 onward this portion of Bhutan has formed part of the Darjeeling District. A fair proportion of the 'Bhutan' collections of Hooker, Griffith and Thomson are from the Kalimpong area. Apart from the earlier scrappy collections of Bhutan, Mr. R. E. Cooper, Curator of the Royal Botanic Garden, Edinburgh, made a substantial collection in Bhutan in 1914. The war prevented the working out of this collection for some time, and the collection was partly destroyed during the war and much of the material is in a dilapidated state, although a substantial portion of the collection, particularly primulas, has been worked out. The writer has also been able to add to his list a few hundred of these plants with the help of Sir William Wright Smith and Mr. Cooper. I have also had the opportunity to collect along the borders of Bhutan and Northern Bengal. His Excellency Sir John Anderson, with Babu H. P. Nasker, one of the Assistants of the Royal Botanic Garden, Calcutta, made a valuable collection from Bhutan proper. But the most important collection which will form the bulk of the Bhutan flora of late, apart from those of older collections, is that of Messrs. Ludlow and Sherriff. They have been accumulating a rich harvest of specimens from many of the hitherto unknown localities of Bhutan since 1933. Some of their plants have

therefore turned out to be new. They have also collected seeds and these are under cultivation at the Royal Botanic Garden, Edinburgh and Royal Botanic Gardens, Kew. I have been able to incorporate the list of the species collected by Messrs. Ludlow and Sherriff by kind permission of Mr. Ramsbottom, Keeper of the British Museum (Natural History), London.

Taking into consideration this fairly substantial material, the plant succession from the subtropical zone to the snow line is in general agreement with the flora of this region as a whole, although, as shown on the table, differing in the composition of the species. I also agree with Captain Kingdon Ward that the density of Rhododendron association is reduced in the extreme north-eastern flanks backing Upper Burma and Szechuan. It is indicated even on the right flanks of Bhutan hill ranges. Comparison, as illustrated in the photographs of the Sikkim and Bhutan areas, indicates such a difference in the nature of the vegetation as one proceeds from Sikkim to Bhutan.

## 11. The Monocotyledonous seedlings of certain Dicotyledons with special reference to the Gesneraceæ.

ARTHUR W. HILL, Kew.

The paper opens with a discussion of certain Dicotyledonous genera whose seedlings normally possess only a single cotyledon instead of the pair typical for Dicotyledons. These include *Cyclamen, Ranunculus Ficaria, Bunium, Erigenia, Corydalis cava, Pinguicula* and *Abronia.* In all these cases there appears to be no support for Miss Sargant's theory that the single cotyledon represents two fused cotyledons. Evidence is produced to show that the second cotyledon may either be rudimentary and capable of development (*Cyclamen*) or wholly suppressed (*Ranunculus Ficaria, Bunium,* etc.). Reference is also made to the apparently monocotyledonous seedlings of the bulbous Peperomias, where one of the two cotyledons never leaves the seed-coat and is a purely absorbent organ.

The various genera of Gesneraceæ, in which one of the two cotyledons of the seedling is arrested in development and ceases to grow, are then considered. These include the Asiatic genera *Chirita, Moultonia, Monophyllea, Didissandra,* and *Didymocarpus* from Indo-Malaya, China, Australia and Tropical Africa: *Streptocarpus* from South Africa and Malaya: *Klugia* from Ceylon and America, and several others. Some of these, such as many species of *Streptocarpus* and a few Chiritas, *Moultonia, Monophyllea, Acanthonema,* etc. possess only one leaf—the enlarged cotyledon—throughout their life-history. Other species of *Streptocarpus* and *Chirita* and also *Saintpaulia* (E. Africa), *Ramondia* (Europe) and others develop a rosette of leaves but no plumular axis, while the third group including most Chiritas, several species of *Streptocarpus, Briggsia* and *Klugia* and some other genera, consists of herbaceous plants with well-developed leafy shoots. In all these cases one of the two cotyledons ceases to grow at an early stage and aborts and, in the case of the caulescent species, no functional axillary bud is developed in its axil.

It is considered that the unifoliate genera and species represent the primitive conditions and that the caulescent forms are derivates from ancestors which had assumed the unifoliate habit, and have been unable, except in rare cases, to recover the use of the second cotyledon whose development has been arrested.

It is further demonstrated that the single leaf of the unifoliate genera and species described is not really the enlarged cotyledon, since the cotyledon itself can be recognized as a persistent tip in many cases on the large, hairy lamina which is the sole leaf of the plant. The 'leaf' arises

as the result of meristemmatic activity at the base of the petiole, in the region where the persistent cotyledon joins the hypocotyl. As a result of this meristematic activity the large lamina of the *Streptocarpus* leaf, reaching to as much as 30 inches long by 22 inches wide in *S. Dunnii*, or the large 'cotyledonary leaves' with long petioles in *Chirita lavandulacea*, etc. are formed.

## 12. The principles of floral construction.

E. R. SAUNDERS, Cambridge.

It is a familiar fact, though often ignored, that the traditional interpretation of the construction of many floral types rests upon suppositions unsupported by any evidence. These suppositions almost invariably take account only of external appearances. When observation is extended to the internal structure—to the vascular system—many prove to be 'morphological fictions' and, moreover, to be entirely superfluous.

It becomes clear from a study of the vascular system that the vascular ground-plan is directly related to the floral ground-plan and exhibits a similar degree of constancy. The nature of this relationship shows that it is no longer necessary to postulate, as hitherto, hypothetical splittings and fusions, 'false' partitions and vanished whorls. The new evidence solves the problem presented by the superposition of successive whorls (one class of case excepted). It leads to a wholly new conception of the construction of the syncarpous gynaeceum. It destroys the fiction of the commissural stigma and the epigynous flower. It throws an entirely fresh light on parietal, axile, basal and free-central placentation; on the gynobasic style; on septicidal dehiscence; and on various other morphological features hitherto unexplained. Among such are the number of styles and stigmas in Ureneæ (Malvaceæ), *Eschscholtzia* (Papaveraceæ), *Aphyllanthes* (Liliaceæ), *Pœpalanthus* (Eriocaulaceæ), and of the partitions in the ovary of *Linum*; the position of the solitary ovule in *Astrocarpus* (Resedaceæ); the dehiscence of the fruit in *Epimedium* (Berberidaceæ); the nature of the difference in the ground-plan of the gynæceum in *Reseda luteola* and *R. odorata*; the fact that in some isomerous types the suppression of a whorl does not affect the position of the succeeding whorl; the fact that obdiplostemony does not occur among Monocotyledons; and other features and interrelations in many families.

## 13. The embryo sac and embryo of *Tamarix chinensis* Lour.

V. PURI, Meerut.

While at Kiel (Germany) Dr P. Maheshwari of Agra collected some material of *Tamarix chinensis* in September 1936 and very kindly passed it on to the author for investigation. The flowers are hermaphrodite but the development of the male gametophyte goes much ahead of the female gametophyte. Usually a single hypodermal archesporial cell becomes differentiated in a narrow bi-tegumentary nucellus. By cutting off a parietal cell it functions as a megaspore mother cell. The nucleus divides twice to produce four megaspore nuclei which do not become separated by walls. The most common arrangement for these nuclei is 1+2+1. Later on the two central nuclei descend into the chalazal end giving rise to a 1+3 arrangement. At the next division the three spindles in the chalazal region fuse together and result in only two nuclei which are larger in size than the micropylar ones and contain 3n chromosomes. Again a four-nucleate embryo sac is produced. The next division results in a normal 8-nucleate embryo sac. The development of the embryo sac is thus after the '*Fritillaria*-type'.

The fertilized egg soon divides by a transverse septum. Some more transverse divisions take place to form a linear row of 6 or 7 cells. Then the apical region swells up to form a bulbous embryo proper while the basal portion forms a spindle-shaped suspensor. Further development results in a typical dicotyledonous embryo.

## 14. A contribution to the knowledge of the wood-anatomy of a few Meliaceæ and Rutaceæ occurring in Bengal.

S. Hedayetullah *and* A. K. Chakravorty, Dacca.

The value of the study of wood anatomy from the systematic point of view has been emphasized.

The importance of statistics in the study of wood-anatomy has been discussed.

Twelve available species of meliaceæ belonging to ten genera and two species of rutaceæ belonging to two genera have been worked out.

Jeffrey's and Schulz's methods have been found suitable for maceration and the cellulose acetate method described by Williamson for softening.

The classification proposed by Kribs on the basis of wood anatomy has been reviewed and the position of *Carapa* and *Cedrela* in the Swietenioideæ has been discussed.

The separation of *Chloroxylon* from the meliaceæ on the basis of wood structure has been confirmed.

Other genera have also been discussed. They confirm mainly the observations of Kribs, with minor differences which are recorded.

## 15. A contribution to the morphology of *Carthamus tinctorius*, Linn.

I. Banerji, Calcutta.

1. The development of the floral parts takes place in the following order :—petals, stamens, sepals and carpels.
2. The development of the microspores appears to be normal and no irregularity has been noted. The meiotic divisions are of the simultaneous type. The haploid number of chromosomes is twelve. A periplasmodium is formed in the anther. The plasmodial substance is deposited on the spiny exine of the pollen grains which then become differentiated as blunt processes. The microspores, before liberation from the microsporangium are uninucleate and have three germ pores.
3. The ovule is anatropous and possesses a single integument and scanty nucellus. During the development of the embryo-sac the single layer of cells enveloping it disintegrates completely and the embryo-sac is enclosed by the integument whose innermost layer becomes differentiated and forms an ' integumental jacket '.
4. A single archesporial cell differentiates in the hypodermal layer of the nucellus and functions as the megaspore mother cell. Two megaspore mother cells have also been observed lying side by side in the hypodermal layer. As a result of the activity of the megaspore mother cell a linear tetrad of megaspores is produced of which the chalazal one gives rise to an eight-nucleate embryo-sac by three successive divisions.
5. The mature embryo sac is of the normal angiospermous type. The nuclei of the antipodal cells divide and the cells become multinucleate.
6. The synergids and the antipodals degenerate before fertilization and the secondary nucleus lies very close to the egg. Fertilization is porogamous. The sperms appear as distinct nuclei.
7. The division of the endosperm nucleus occurs prior to that of the egg and the endosperm is of the nuclear type. The zygote divides first by a transverse wall. The further development of the embryo appears to be of the *Capsella* type.

## 16. On the floristic elements of the flora of Bengal, Bihar and Orissa and their origin.

A. K. Ghosh, Calcutta.

In this paper are summarized the results of a study of the distribution of about 1,200 species of trees, shrubs, undershrubs and perennial herbs, occurring within the boundaries of Bengal, Bihar and Orissa excluding the Himalayas.

This area is divided into the following 8 sub-areas, based mainly on the climatic factors, viz., temperature, rainfall and relative humidity.

| | | | |
|---|---|---|---|
| I. | *Coastal Orissa.* | V. | *E. Bengal.* |
| II. | *Orissa proper.* | VI. | *Chittagong.* |
| III. | *Chotanagpur.* | VII. | *Bihar.* |
| IV. | *Sundribans.* | VIII. | *W. Bengal and C. Bengal.* |

Floristically areas II and III form part of the Deccan province areas I, IV, VII and VIII form the province of the Lower Gangetic Plain, and the areas V and VI are included within the N.-W. Burman province.

An attempt has been made to indicate the source from which these species have entered the area investigated by a study of their means of dispersal and their total distribution.

The routes by which migration of the species has taken place are shown on a map which will be exhibited. The various elements composing the flora are as follows :—

1. The *Bengal element* or the element represented by the Lower Gangetic Plain.
2. The *Malabar element.* A large number of endemic species have been produced in this area and have thence entered Bengal.
3. The *Upper Burmese element,* representing the sub-tropical rain forest element of Assam and N. Burma.
4. The *Afro-Arabian element* which entered the Indian area from the west.
5. The *Chinese element,* hardly extending beyond the Himalayas.
6. The *Himalayan element* ; this has also produced endemic species.
7. The *Malayan element,* many species of which are dispersed by the sea and are carried to the Gangetic delta (Sundribans) and thence carried further inwards.
8. The *Burmese element* which has produced a large number of endemic species within the area.
9. The *Oriental element* migrating from the Mediterranean through N.-W. India.

## 17. A contribution to the life-history and cytology of some Panjab Zygophyllaceæ.

S. L. Ghose *and* Dilawar Hussain, Lahore.

1. Observations on the micro- and mega-sporogenesis of *Tribulus terrestris* and *Peganum Harmala* are recorded.
2. No periplasmodium was seen to be formed.
3. The second contraction of the spireme has been observed in heterotypic division.
4. In *T. terrestris* sometimes all microspores of a tetrad may disintegrate.
5. In *P. Harmala* cytokinesis takes place by furrowing.
6. The generative cell is lens-shaped.
7. In *P. Harmala* the megasporangial archesporium is many celled, but only one of the cells is functional.
8. In both plants a primary wall cell is cut off in megasporogenesis.
9. The synergids are hooked and the three antipodals lie in one row.

## Genetics and Cytology

(*Chairman* : Dr. E. K. Janaki Ammal.)

### 18. The biology of crossing-over.

C. D. Darlington, London.

Two important changes take place at meiosis: reduction in the number of chromosomes by the segregation of partners and crossing-over between those partners. Crossing-over takes place as a result of a torsion developed in the paired chromosome threads. This torsion twists the threads round one another until an equilibrium is reached like that reached in the operation of spinning. The chromosomes divide, the equilibrium is upset and the daughter threads break at opposite points; the broken ends twist and rejoin: crossing-over has taken place.

Since attraction is limited to pairs of threads, division of each chromosome into a pair of threads causes the partners to fall apart. But since crossing-over takes place at the same time and produces an exchange of partner amongst the threads, all four threads remain held together at the points of exchange or chiasmata. All the later association of the chromosomes and hence their segregation and reduction depends on these chiasmata.

Crossing-over is not therefore merely a genetical incident in the segregation of chromosomes at meiosis. It is the mechanical *conditio sine qua non* of meiosis and hence of sexual reproduction. From this fundamental effect of crossing-over we must distinguish its incidental effects. These are of two kinds. First it simply recombines the parts of the chromosomes, or genes, without changing their arrangements. Secondly in structural and numerical hybrids it has the special effect of altering the arrangement of the genes and producing in the already changed chromosomes secondary changes. Such changes are responsible for the attachment of X and Y chromosomes in *Drosophila*, the production of several kinds of mutants in the hybrid species of *Oenothera* and the fragmentation of chromosomes in many known interspecific hybrids.

We do not yet know how important secondary structural change may be, but it is probably an integral part of the mechanism of variation in all sexually reproducing organisms. The incidental effect of crossing-over has thus become as important as the fundamental and original one.

### 19. Structure of the meiotic chromosomes of *Hosta Sieboldiana* Hosk.

H. K. Nandi, Calcutta.

A detailed investigation of the present material furnishes evidence to show that the chromosomes exist as spiral threads in all the stages of chromosome cycle.

At the heterotypic prophase the 'chromomeric' appearance of the leptotene and zygotene threads are seen as optical images produced by twists of the finely coiled spiral structure of the lower order.

At diplotene each homologue shows indication of doubleness resulting in quadripartite structure. It can now also be seen that the chromatids have exchanged partners thus forming chiasmata.

At diakinesis each chromatid is seen as a doubly coiled structure composed of major and minor spirals which are fitted into the spiral of its partner.

The bivalent chromosomes at metaphase are shorter and thicker. This shortening is due to the development of the major spiralling or

spiralling of higher order. The double coiled nature of each chromatid is clearly demonstrable by ammonia treatment.

As the chromosomes reach the poles at anaphase I, they become drawn out when the tension of the major spiral is released. The sister chromatids become separated except at the spindle-attachment region.

At telophase the major spirals still expand due to the relaxation of the coils and also because the matrix of the chromosomes is exuded out to contribute to the formation of the nucleolus. The minor spiral or spiral of the lower order is now clearly visible.

The chromosomes in the homotypic metaphase show spiral structure in which the gyres are of smaller diameter and larger in number than those of the spirals of the heterotypic metaphase chromosomes, i.e. spirals of the higher order.

Convincing evidence of the presence of coiled chromonema throughout all the phases of chromosome history substantiates the theory that the individuality and continuity of the chromosomes is maintained from one cell generation to another and suggest that spiralization is a mechanism essential for the preservation of the linear order of the genes.

## 20. Cytogenetical studies on jute.

H. K. NANDI, Calcutta.

The diploid chromosome number of *Corchorus capsularis* Willd., is $2n = 14$. No other deviating number with less or more chromosomes has been reported in the species or varieties of jute.

The writer in the course of his cytogenetical studies discovered a variant plant in the jute cultures which is characterized by much smaller and deeply serrated leaves quite different from the normal varieties. The plant is bushy in nature and profusely branched. The two hood-like appendages generally present at the base of the lamina in the normal varieties are totally absent in the variant. Flower buds are much smaller, stamens fewer in number ranging from 10-16, the normal with 15–24. Some of the stamens in the mutant are transformed into petals. Anthers are generally empty with deformed and aborted pollen grains. Ovary with a very short style and trifid or 4-fid stigmas, the normal with a long style and undivided stigma. Capsule smaller with very few seeds.

Cytological studies have revealed 15 chromosomes in the root-tip cells. This is further corroborated by studies of the pollen mother cells. The variant is therefore a trisomic mutation ($2n+1$).

Study of the pollen mother cells at diakinesis revealed six pairs of bivalents and a trivalent as also seven pairs of bivalents and an univalent. At anaphase I and II, eight and seven chromosomes could be seen passing to the daughter cells. Sometimes a lagging univalent was noticed in the first and second division.

The trisomic thus produces dimorphic gametes with 8 and 7 chromosomes. The breeding behaviour of the mutant shows that when the trisomic is selfed, it produces a high percentage of mutants in the $F_1$. When the trisomic is used as male and the normal as the female, the percentage of trisomic mutation is considerably reduced in the $F_1$ progeny. This shows that egg cells with one extra chromosome are more effective in fertilization and in the transmission of mutant characters.

Studies of the normal variety from which the mutant arose have shown failure of pairing of one bivalent in the pollen mother cells. This gives rise to gametes with 8 and 6 chromosomes. Similarly it is expected that such things happen in the megaspore division. The trisomic most probably arises from the union of an egg cell with 8-chromosome gamete and a 7-chromosome pollen.

Clear evidence of secondary association is observed for the first time in jute. The maximum association is two groups of two bivalents, the

other three bivalents remaining separate. It is therefore suggested that the basic number of *C. capsularis* is $b = 5$, the present number $n = 7$, is secondarily balanced.

## 21. Chromosome behaviour in Saccharum spontaneum × Sorghum durra hybrids.

(MISS) E. K. JANAKI AMMAL, Coimbatore.

Twelve out of thirteen hybrids between *Saccharum spontaneum* ($2n = 56$) and *Sorghum durra* ($2n = 20$) had $2n = 38$ chromosomes, and a single 'triploid' hybrid plant (containing two sets of *S. spontaneum* chromosomes and one set of *Sorghum*) had $2n = 66$. The characteristic 'A' chromosomes with a prominent sub-terminal attachment constriction, which is found in the genus *Sorghum*, could be identified in all the plants examined. A comparative study of meiosis and an analysis of chromosome pairing in both types of hybrids is presented.

## 22. The structure of the chromosome.

R. RUGGLES GATES, London.

All the recent critical work has decided against the chromomere theory and in favour of the theory of a chromonema or thread of uniform thickness composing the essential part of the chromosome in plants. Animal cytologists still frequently adhere to the chromomere hypothesis, but it appears unlikely that such a fundamental difference in structure exists between plant and animal chromosomes.

Critical observations of plant and animal chromosomes indicate that the chromosome is always at least a two-stranded structure, each of the strands which is about to separate in metaphase undergoing a split in prometaphase. It is possible that the chromosome may even be four-stranded, as the work of certain investigators suggests. The individual threads are spirals throughout the mitotic cycle, reaching the maximum of condensation at metaphase and being drawn out so that they more or less completely lose their spirality in the resting stage. The spiral itself may be ultimately related to the structure of the protein molecule.

Recent work on the satellites in relation to the nucleolus represents one of the most important advances in our knowledge of nuclear structure. Studies of rice, wheat and various other plants show that the history of the satellites and their relation to the nucleoli can be used as an important method of confirming or altering conclusions drawn from secondary pairing. In this way secondary polyploids can be discovered and the phylogenetic history of the nucleus from genus to genus can be read in its structure. This method is destined to throw much light on intergeneric relationships where changes in chromosome number are involved. The nature of the thread attaching a satellite to its chromosome needs further study.

The salivary chromosomes of insect larvæ, with their enormous size and conspicuous pattern of chromatin discs apparently corresponding to genes, appeared to offer great hopes of further understanding of chromosome structure. But recent observations and conclusions have been so divergent and contradictory that this hope has not been fulfilled.

The numerous similarities in the structure of animal and plant chromosomes and their similar relationship to the nucleolus in the higher organisms, together with divergencies in such groups as the Protozoa and the Rhodophyceæ, indicate a great deal of parallel evolution in the nuclei of higher plants and animals.

## Mycology and Plant Pathology

(*Chairman* : PROF. K. C. MEHTA.)

### 23. Host range and identity of the smut causing root-galls in the genus *Brassica.*

B. B. MUNDKUR, New Delhi.

Symptoms of a smut which produces root-galls in *Brassica campestris* L., are described and it is shown by pot experiments, that considerable reduction in yields may be caused as a result of attack by this fungus. The smut is soil-borne and the galls are capable of spreading the disease from place to place.

Besides mustard, several other species of *Brassica* including radish, turnip and cabbage are attacked by it.

This smut is not capable of infecting *Turritis glabra* and *Matthiola sinuata,* species that are susceptible to *Urocystis coralloides.* This fact, and the spore-measurements indicate that the Indian smut is not *U. coralloides* and that it is a new species. The name *Urocystis brassicæ* is therefore proposed for it.

### 24. On a new Ravenelia from India.

B. B. MUNDKUR *and* N. PRASAD, New Delhi.

A rust which belongs to the genus *Ravenelia* was found affecting *Acacia modesta* Wall., near the Imperial Agricultural Research Institute, New Delhi. Collections were made on January 6th and February 26th, 1937. Pycnial. aecial and uredial stages were not present. The telial heads borne on short, hyaline, deciduous stalks, measured 83–128$\mu$ in diameter ; they are convex, hemispherical to orbicular, and alantoid in side-view. The teliospores are unicellular, 10–12 across, with epispore 5-7$\mu$ thick at apex. The cysts are pendent, oblong-ovate and their number is the same as the number of single cells in the head. *Ravenelia* belongs to the sub-section Haploravenelia and on comparison with other species reported to occur on the genus *Acacia,* this specimen has been found to be a new species. The name *Ravenelia Taslimii* Mundkur nov. sp., is proposed for it.

### 25. Effect of the locality and the time of sowing on the incidence of 'Spot blotch' disease of barley.

M. MITRA, New Delhi.

While studying the 'Spot blotch' disease of barley caused by *Helminthosporium sativum,* the author has observed: (1) that the incidence of the disease varies from year to year, (2) that in the same year the range of variation in infection in different plots was quite marked although the seed had been sown on the same date, (3) that within the same type which was sown on different dates in different plots, the percentage of leaf area destroyed by *H. sativum* varied from 1·37–7·83, which is indeed a wide range, (4) that within the same plot, the portion of land on which seed was sown earlier showed more disease. Environmental factors such as temperature, humidity, soil type, etc. play an important part in the development of 'Spot blotch' disease of barley.

### 26. Competition in fungi.

T. S. SADASIVAN, Lucknow.

A number of fungi, *Fusarium* sp., *Helminthosporium* sp., *Gibberella* sp., *Monilia* sp., *Phoma* sp., and *Dendryphiella* sp., were used in order

to ascertain the nature of competition in fungi, by allowing them to compete in media differing in composition of acid, alkali and nutritive chemicals. Inocula were placed mixed, adjacent and 2 cm. apart. Interesting results were obtained with two fungi—a species of *Fusarium* and a species of *Dendryphiella*. Some of the more important points observed were :

1. In the standard synthetic medium both the strains had almost the same rate of growth making it possible for them to compete on more or less equal terms.
2. In all cases where the inocula were placed adjacently, the mutual reaction between the two fungi was more pronounced.
3. In the malic acid media *Dendryphiella* remained recessive in the adjacent cultures up to 1·0% and then was dominant till 1·75% when both the strains ceased growth.
4. In the NaOH media, in the adjacent cultures, *Fusariam* was recessive up to 0·25% (after fluctuating in the lower strengths) and dominated over *Dendryphiella* till 0·5% when the growth of both came to an end.
5. In the adjacent cultures in the $Na_2CO_3$ media, *Fusarium* was dominant throughout the series and *Dendryphiella* stopped growth completely at 0·15% (after fluctuating in the lower strengths) while *Fusarium* grew on unhampered.
6. In $KNO_3$ media, in the adjacent cultures, *Dendryphiella* dominated up to 0·75% and then *Fusarium* took the upper hand and finally overcame *Dendryphiella* by completely stopping *Dendryphiella* growth at 10·0%.
7. In the adjacent cultures in the Glucose series *Fusarium* was throughout dominant from 0·1 to 12·0% and *Dendryphiella* recessive with three points of complete inhibition at percentages 0·1, 0·2, and 0·4.
8. In all cases where the fungi have been inoculated adjacent and 2 cm. apart, the growth rate increased and complete inhibition took place at a higher percentage of the different acids, alkalis, etc. as compared with the controls.

I wish to express my grateful thanks to Dr. S. N. Das Gupta for suggesting this problem and offering me ready guidance and criticism throughout.

### 27. The sexual process in fungi.

A. H. R. Buller, Kew.

## Physiology and Ecology

(*Chairman* : Prof. P. Parija.)

### 28. Studies on the effect of definite doses of alcohol on the activity of certain enzymes in the leaf of *Eugenia jambolana*.

U. N. Chatterji, Allahabad.

Experiments were carried out with a view to find out the effect of alcohol-injection on the activity of certain enzymes in the leaves of *Eugenia jambolana*. Definite doses of ethyl alcohol, $CH_3CH_2OH$, were injected, the percentages ranging from 2 to 15. The enzymes studied were diastase and catalase.

It was seen that alcohol-injection increased the activity of these enzymes, the highest stimulation obtained was by a 5% dose in the case of diastase, and 8% dose in the case of catalase. The increase in the activity of diastase corresponds with increase in respiratory carbon dioxide output as enhanced by alcohol.

Beyond 5% and 8% alcohol-injection there is a progressive fall in the activity of these enzymes.

It has also been found that alcohol-injection reduces the hydrogen-ion concentration of the leaves or increases the pH. It seems that alcohol-injection shifts the pH to a value nearer the optimum for diastase and by reducing the medium from a more to a less acidic one increases the catalase activity. The acceleration of both the enzymes diminishes considerably after 24 hours.

## 29. The effect of carbon dioxide on water entry into the roots.

T. EKAMBARAM *and* V. K. KAMALAM, Madras.

1. Absorption of water by the roots of Tomato and *Erythrina indica*. in water with $CO_2$ dissolved in different concentrations was studied.

2. In Tomato, there was an initial fall, a subsequent rise and a final fall in the rate of absorption with high concentrations. There was no effect with lower concentrations. In *Erythrina*, water saturated with $CO_2$ caused depression but no effect was observed with high concentrations as in Tomato. But depression occurred when kept in higher concentrations for longer periods. With lower concentrations there was no effect.

3. That no oxygen was supplied in the solution is emphasized.

## 30. Permeability of the xylem vessel wall.

T. EKAMBARAM *and* V. K. KAMALAM, Madras.

1. Cut ends of the shoots of *Tecoma Stans* were placed in 10% solutions of 24 different chemicals.

2. As the solution ascended into the shoot, two types of killing of the living cells in the stem and leaves were observed (1) the acetic acid type in which the cells adjoining the xylem vessels in the stem and the cells along the veins in the leaves were first killed, and (2) the Potassium Nitrate type in which the cells in the stem along the vessels were not killed but the killing started in the groups of mesophyll cells at the vein endings, (3) it is inferred that the wall of the xylem vessel is not equally permeable to all the different solutes present in the transpiration stream, as is generally assumed.

## 31. Studies in the physiology of spike disease of sandal.

A. V. VARADARAJA IYENGAR, Bangalore.

1. *Mineral nutrition of sandal in relation to health and disease.*—A chemical examination of healthy and spiked plants revealed an abnormal metabolism of calcium and nitrogen in the diseased ones. While the affected leaves and twigs showed a diminished lime and potash, the corresponding roots were significantly rich in these constituents. There appears to be a mobilization of nitrogen reserve from the roots to stems and leaves which had a high nitrogen content. In any case, the ratio Ca/N is the surest index of disease in sandal.

II. *Carbohydrate metabolism of spiked sandal.*—The diseased tissues are characterized by an accumulation of starch from incipient stages of infection. This storage is traceable to a defective translocation of food materials with the onset of spike. In the advanced stages, the leaves are packed with starch and are also rich in soluble carbohydrates. The mechanism of excess sugar formation is probably from the fats already present in the leaves which, as a result of infection show a lower fat content. This heavy starch deposition can be readily accounted for, if a deficiency in calcium following infection is assumed.

III. *Nitrogen content of healthy and spiked sandal tissues.*—Although the nitrogen content of tissues changes considerably with the

inception of disease. comparatively little is known of the distribution of nitrogen in the various plant parts. In the leaves, however, water soluble nitrogen was higher as a result of infection while protein nitrogen was relatively small. Further, the increase in ammoniacal nitrogen in the diseased condition is due to the presence of deaminase functioning therein.

IV. *Tannins and organic acids in health and disease.*—It is known that organic acids and tannins contribute towards the resistance of plants to disease and to insect attack. In the case of spike, all that is known relates to the preponderance of hydroxy acids such as malic and citric, in the early stages of disease, which are also distinguished by a high moisture content of spiked leaves. With the advance of disease or in virulent stages of infection, the presence of succinic acid exclusively in the affected tissues has been recorded. A process of desiccation also takes place with the progress of disease. This increase in organic acids combined with a high ammonia content is correlated with the occurrence of a highly active deaminase. The presence of an oxidative deaminase system would easily account for the formation of succinic acid. The possibility of this acid arising through dehydrogenase action on acetic acid has been tested with negative results. In healthy plants, malic acid is the chief component. The buffering action of diseased leaf juice is strong towards alkalies while it is weak towards dilute acids. This seems possible only when the respiratory activity is unusually high as in the present instance.

There is a distinct change in the nature of tannins with the onset of disease. While both pyrogallol and pyrocatechol groups of tannins have been found in sandal leaves the former type predominates in the diseased condition. In healthy ones, on the other hand, the catechol group is the chief component. These two types are found to affect the metabolic processes in different ways. The total tannin content however of spiked leaf tissues is twice that found for healthy ones. How this transformation takes place from one type to the other has not been examined.

V. *Metabolic disturbances in sandal leaves consequent on spike infection.*—Diseased leaves are characterized by a high diastatic activity. A greater deposition of starch than the normal is generally correlated by the physiologist with a low amylase co tent or a feeble diasta' ic action. In the present case, however, the increased enzymic power was traced to the presence of an activator in the form o pyrogallol group of tannins rather than to a higher enzyme unit. Correspondingly, catechol type is very poor in action.

The respiratory activity of spiked leaves alone was high while the corresponding twigs showed a less activity. Tender leaves however respire more carbon dioxide than mature ones. The presence of a powerful deaminase in spiked leaves was also established. Further work on this is in progress.

Photosynthetic activity of diseased leaves is comparatively less than that of healthy ones. The translocation of food material in sandal appears to be inhibited with the onset of infection.

## 32. Some observations on the structure of adhesive discs in climbing plants.

T. S. MAHABALE, Ahmedabad.

Adhesive discs were noted in *Vitis latifolia* Roxb., *V. trifolia* L., *V. carnosa* Wall, *V. repanda* Wight, *Luffa aegyptiaca* Mill, *L. acutangula* Roxb., *L. acutangula* Roxb. var. *amara* Roxb., *Trichosanthes cucumerina* Linn., *T. palmata* Roxb., *Melothria maderaspatana* Cogniaux., *B. venusta* Ker-Gawl., and their anatomy was studied with a view to follow the mechanism of adhesion. It was found that the main structural elements of a disc are constant in the various species examined.

In a transverse section of a disc the outermost layer is made up of sensory epithelium and hairs. Below this layer lies thin walled parenchyma with turgid cells; sometimes these are associated with cells having transverse pits on their walls. In a longitudinal section cells below the subjacent parenchyma, which are outside the stele, have starch granules lying on the physically lower side of the cells, strongly recalling statoliths.

Protoplasts in the sensory hairs undergo physical distortion when they come in contact with a hard and rough surface and thus seem to perceive the stimulus. Cells below the sensory layer are thin walled turgid, and somewhat elongated. Presumably they conduct the stimulus to the statocysts, create a disturbance in the statoliths, resulting in an appropriate curvature of the tendril. This, we may reasonably suppose, allows the sensory hairs to grasp the support and cement it. Mechanical elements are laid down next and adhesion becomes permanent after about twenty-four to forty-eight hours. It is suggested, therefore, that the structural peculiarities of the discs and the statoliths noted for the first time in them, are largely responsible for the mechanism of adhesion. Experimental work is in progress.

## 33. The effect of light on lipase activity.

N. L. PAL, Allahabad.

Effect of artificial light on the activity of lipase, a fat splitting enzyme, was studied. It was found that light had very little action on the hydrolysing capacity of lipase: but there was considerably greater condensation by lipase in light specially in the earlier periods, though light is not at all essential for this action. Thus there was greater synthesis of fat from fatty acids and glycerine by lipase in light than in dark.

## 34. The effect of light on respiration and conversion of fat to sugar in germinating Helianthus seeds.

N. L. PAL, Allahabad.

The rate of $CO_2$ output and oxygen intake goes on increasing with time in germinating *Helianthus* seeds and the respiration generally corresponds with the grand period of growth.

In the stages examined the R.Q. shows a fall from about 0·75 to 0·54 as the plants grow in length.

On exposure to light the $CO_2$ output and the $O_2$ intake show a fall thereby showing that some amount of photosynthesis is possible even in such young plants as these.

On the assumption that the R.Q. due to respiration is unity, the amount of oxygen taken in for fat to sugar conversion can be calculated. It is shown that this value rises progressively in dark and the rate of rise increases with time. However, on exposure to light there is not only a retardation in the rate of increase, there is an actual fall in later periods in light.

It has therefore been argued that the rate of fat to sugar conversion falls on exposure to light in these seeds.

## 35. The effect of violet and ultra-violet radiations on plant respiration.

S. RANJAN, Allahabad.

(1) The effect of light from an atmospheric murcury vapour lamp on plant respiration was studied. It was found that owing to a great reduction in the ultra-violet part of radiation, due to glass surfaces through which the light passed, and owing to the presence of other rays

in the light the effect was more or less similar to the effect of ordinary light on respiration.

(2) When exposed to rays passing through methyl violet solution so as to give monochromatic violet light, the respiration rate does not show any appreciable change.

(3) However, on exposure (8 minutes and 10 minutes at an interval of 2 hours) to direct light from this apparatus at a distance of 1 ft. containing a much greater proportion of ultra-violet radiation, the respiration of leaves shows a fall which slightly rises on switching off the light. Shorter exposures (3 minutes from a distance of one ft. at an interval of one hour) clearly proves the inhibitory effect of ultra-violet radiation on respiration. Weaker doses (3 minutes at a distance of 6 ft.) also have harmful effects though the inhibition is less marked.

(4) Sugar estimations show that there is no change in the reducing sugar content exposure to ultra-violet light.

## Palæobotany

(*Chairman* : PROF. B. SAHNI.)

### 36. An analysis of the artificial genus *Palmoxylon* into natural genera.

K. N. KAUL, Lucknow.

In 1888 F. H. Knowlton (*Proc. U.S. National Mus.* : 89–91) wrote, 'So little is at present known regarding the internal structure of the living species that it is only possible in the present state of our knowledge to mass together all the fossil species under the comprehensive generic name of *Palmoxylon*, or simply "Palm-wood". It is true that the described species of *Palmoxylon* differ considerably among themselves and it is more than probable that characters will ultimately be obtained that will allow of a separation into several generic types.' Stenzel (1904 *Fossile Palmenhölzer, Beiträge zur Palæontologie und Geologie* : 123) had already noticed that the structure of the ground-tissue was distinctive of the different species of fossil palms.

In 1934-35 on the suggestion of Professor B. Sahni I investigated the stem anatomy of 63 species (belonging to 33 genera) of modern palms in the hope of finding vegetative characters which should enable one to make a natural classification of the Palmæ. As I then stated (Kaul, 1935, *Ind. Sci. Congr., Bot. Sec.*, Calcutta : 285-6) the characters of the ground-tissue, which takes its definitive form after the growth in thickness of the stem (see Schoute, 1912, '*Ueber das Dickenwachstum der Palmen*', *Ann. Jard. Bot. Buit.*, xi: 1–209) are of great value for distinguishing natural genera of palms. I then suggested that it is possible to classify the different genera on the basis of the ground tissue characters alone; also that if this claim was justified, the highly artificial form genus *Palmoxylon* could be split up into a number of natural genera of which the affinities or even identity with modern genera could be ascertained with some confidence.

By a detailed comparison of the living species with the extensive fossil material, which Professor Sahni has been describing in an unpublished monograph, it has been found that *Palmoxylon coronatum* Sahni so closely resembles the modern palmyra palm, *Borassus flabellifer*, in all its anatomical characters, including the ground-tissue, as to raise the suspicion that the fossil species may actually be a petrified palmyra. Between the fossil species *P. mathuri* Sahni and *P. sundaram* Sahni on the one hand and the modern palms *Bactris pallidispina* and *Cocos nucifera* respectively on the other, there are also such close anatomical resemblances that I believe the fossil forms belong to these living genera.

More extensive comparisons now in hand will, it is hoped, make it possible to split up the artificial genus *Palmoxylon* into its component natural genera.

## 37. A Lower Gondwana flora from the Salt Range, Punjab.

(MISS) CHINNA-VIRKKI, Lucknow.

These fossils, presented to Prof. B. Sahni by Mr. E. R. Gee, who collected them from two different horizons (a lower horizon A and a higher B), were kindly entrusted to the authoress for further investigation. The collection from A is important, as it belongs to the lowest plant-bearing horizon so far discovered in the Indian Gondwanas. It comes from the carbonaceous shales of the basal portion of the Speckled Sandstone series. from a horizon only about 20–25 ft. above the Talchir Boulder bed (Upper Carboniferous). Horizon B is formed by the carbonaceous shales just below the massive Middle Productus Limestones (Middle Permian). The material consists of incrustations and impressions. Cuticular preparations were made from the specimens marked *. Maceration of some of the shales yielded spores, which are recorded for the first time from the Palæozoic rocks of India. The identifications given below are provisional :—

| | Horizon A. | Horizon B. |
|---|---|---|
| EQUISETALES. | ? *Schizoneura* sp. | |
| CYCADOFILICALES. | Frond (fertile). | |
| | *Sphenopteris* sp. | |
| | ? *Pecopteris* sp. | ? *Pecopteris* sp. |
| | *Glossopteris Communis*, Fstm. | |
| | *G. communis* var. *stenoneura*, Fstm. | |
| | *G. stricta*, Bunb. | *Glossopteris stricta* Bunb. |
| | *Glossopteris* spp. (two). | * *Glossopteris* spp. (three). |
| | * *Gangamopteris* spp. (three). | *Vertebraria* sp. |
| GYMNOSPERM SEEDS | *Cardiocarpus* sp. | |
| | *Samaropsis* spp. (two). | |
| INCERTÆ SEDIS. | * Piece of cuticle with irregularly arranged cells. | * Narrow leaves with parallel veins. Cuticle resembles that of *Bennettitales* : transversely placed stomata arranged in rows. cell walls sinuous. |
| | *Ottokaria*-like frond, stalk long, margin round, base cordate, apex notched. | |

SPORES (mostly from B) of varied shape and form and ranging from $25\mu \times 11\mu$ to $150\mu \times 110\mu$, can be classified as—

(i) Unwinged—(twelve different kinds) smooth walled, tuberculate or spinous ; shape triangular, elliptic or oval.

(ii) Winged—

(*a*) one wing all round,

(*b*) two wings (cf. *Pityosporites antarcticus* Seward).

(*c*) Three wings.

*P.S.*—Since the above was written I have visited the locality (Kathwai) where the lower horizon (A) mentioned above is exposed. In

the same geological section two new plant-bearing horizons, only 1½ ft. and 4½ ft. above the Talchir Boulder Bed, were discovered, and from these horizons spores identical with some of those above described were obtained. These two horizons are now therefore the lowest plant-bearing Gondwana horizons yet recorded from India.

## 38. Jurassic plants from Afghan-Turkistan.

R. V. SITHOLEY, Lucknow.

This collection by Dr. C. S. Fox of the Geological Survey of India, lent to the author by Prof. Sahni, is interesting because it comes from definite horizons in isolated and remote localities.

The following is a provisional list :—

| | |
|---|---|
| EQUISETALES .. | *Equisetites* sp. |
| FILICALES .. | *Cladophlebis denticulata* Brongn. |
| | *Matonia*-like fronds (fragments including only bases of radiating pinnæ). |
| | ? *Laccopteris* sp. (pinnate fragments with a possibly reticulate venation). |
| | *Coniopteris hymenophylloides* Brongn. |
| | *Sphenopteris* sp. |
| | ? *Haydenia thyrsopteroides* Seward. (sterile). |
| | *Dictyophyllum* sp. |
| CYCADOPHYTA .. | *Nilssonia saighanensis* Seward. |
| | *Ctenis* sp. |
| CONIFERALES .. | *Pagiophyllum* sp. |
| | Cones probably of *Pagiophyllum* sp. |
| | *Mesembrioxylon* sp. |
| INCERTÆ SEDIS .. | Axis bearing ? fructifications (cf. *Discostrobus argunensis* Krasser). |
| | *Podozamites lanceolatus* L. & H. |
| | ,, ,, L. & H. var. *latifolius* Heer. |
| | ,, ,, L. & H. *angustifolius* Seward. |
| | ,, sp. |

Fronds of *Matonia*-like habit are rare for this area, though *Dictyophyllum* has been reported from Afghanistan. In India, the first Matoniaceous fern (*Matonidium indicum*) has been described only recently by Prof. Sahni from the Lower Cretaceous (Wealden) of Himmatnagar (W. India). A fuller identification of the *Matonia*-like fronds from Afghan-Turkistan may throw more light on the geological distribution of the *Matonia-Dipteris* alliance.

As most of the specimens are either identical or closely allied to species described by Seward (*Palæont. Ind. New Series*, Vol. IV, No. 4, 1912) from Afghanistan, which he considers Jurassic, it appears reasonable to assign the same age to the Afghan-Turkistan beds.

## 39. Two petrified strobili from the Rajmahal Hills, Bihar.

A. R. RAO, Lucknow.

The description of the following types is based upon the study of some silicified blocks from Nipania (Jurassic) a preliminary account of which has already appeared (*Rao, Proc. Ind. Sci. Congress* 1934 and *Sahni, Proc. Zesde Internat. Bot. Congress, Amsterdam*, II, p. 248, 1935).

*Nipaniostrobus Sahnii* gen. et sp. nov.

Megastrobilus (possibly coniferous) with spirally arranged sporophylls each bearing adaxially a single ovule ($1 \cdot 5 \times \cdot 5$ mm.) partly buried in the

scale ; micropyle strongly curved, slit-like, facing the cone axis. Integument two layered, not fleshy ; outer (prismatic) layer thicker at the chalazal end of the ovule. Nucellus shrunken, with a black tip. The cone differs from all known fossil forms. The single ovule on each scale suggests the Podocarpineæ but further details are lacking. The real affinities are therefore quite obscure.

*Masculostrobus rajmahalensis* sp. nov.

Fragment of a longitudinally cut microstrobilus with sporophylls placed in a close spiral; distal sterile lobes upturned and overlapping. Sporangia full of two-winged pollen grains (cf. Abietineæ and Podocarpineæ) measuring $54–60\mu \times 30–34\mu$ including wings, spore diameter about $30\mu$.

The material was lent by the Geological Survey of India to Professor Sahni at whose suggestion this work was undertaken.

## 40. Jurassic plants from Tabbowa, N.-W. Ceylon.

K. Jacob, Lucknow.

The fossils here dealt with were collected last June by the author in the company of Mr. T. S. Sadasivan from certain plant-bearing beds at Tabbowa in the North-West Province of Ceylon. The beds consist of non-marine deposits composed of sandstones, pipe-clay and ironstones. A few fragmentary plant fossils collected by E. J. Wayland were first described from this locality by Seward and Holttum (*Quart. Journ. Geol. Soc.*, Vol. lxxviii, pt. 3, 1922). The specimens in our collection are better preserved ; besides, several species not recorded from this locality (marked *) are also represented. The following is a provisional list :—

* *Sphenopteris* sp.
* *Coniopteris hymenophylloides* Brongn.
* *Cladophlebis cf. C. whitbyensis* (Göpp.).
* *Cladophlebis* sp.
*Taeniopteris spatulata* McCl.
* *Anomozamites* sp.
*Brachyphyllum mamillare* Brongn.
*Elatocladus plana* (Fst.).
? *Desmiophyllum* sp.

The flora, as already concluded by Seward and Holttum (*loc. cit.*), is undoubtedly of Jurassic age, and the locality represents one of the outliers of the Upper Gondwanas of the Coromandel Coast.

## 41. Fossil plants from Sakrigalighat in the Rajmahal Hills, with remarks on the age of the beds.

K. Jacob, Lucknow.

The plant-bearing beds consist of two main zones—a lower brittle zone (A) and an upper hard zone (B) (Jacob, *Proc. Ind. Acad. Sci.*, B, Vol. VI, 1937). From the latter only impressions were obtained, while the former yielded besides impressions, a number of non-carbonized incrustations as well. 'Film-transfers' and microtome sections of the chemically treated incrustations gave satisfactory results. The following is a provisional list of species collected from the two zones :—

| | |
|---|---|
| Equisetales .. .. | *Equisetites* sp. (A). |
| Filicales .. .. | *Sphenopteris* (? *Coniopteris*) sp. (A).<br>*Coniopteris hymenophylloides* Brongn. (A).<br>? *Thinnfeldia* sp. (A).<br>*Cladophlebis indica* O. & M. (A). Certain anatomical features of the midrib are seen. |

| | |
|---|---|
| | *Protocyathea rajmahalense* Jacob (l.c. 1937). (B). |
| Cycadophyta .. .. | *Ptilophyllum acutifolium* (Morr.). (A) and (B). Certain anatomical features of the midrib are seen. |
| | *P. tenerrimum* Fst. (B). |
| | * *Dictyozamites* sp. (A). |
| | *Taeniopteris spatulata* McCl. (A). |
| | *Taeniopteris* sp. (A). The structure of stomata is described. |
| | *Nilssonia Morrisiana* Old. (A) and (B). |
| Coniferales .. .. | ? * *Elatocladus conferta* (O. & M.). (A). |
| | ? * *Elatocladus* cf. *E. jabalpurensis* (Fst.). (B). |
| | *Brachyphyllum expansum* (Sternb.). (B). |
| | *Pagiophyllum peregrinum* (L. & H.). (A) and (B). |
| | * *Dadoxylon* sp. A rolled pebble, possibly from a different horizon. |
| | ? *Frenelopsis* sp. (A). |
| Caytoniales .. .. | *Sagenopteris Bhambhanii* sp. nov. (A). The genus is for the first time described from the Indian rocks. Occasional anastomoses between the bifurcating arched secondary veins. |
| Incertæ .. .. | *Sakristrobus Sahnii* gen. et sp. nov. (A). Strobili of slender habit with delicate sporophylls arranged on an axis. Each sporophyll consists of a 'stalk' and a peltate lamina with reproductive bodies (? sporangia) arranged probably all round the 'stalk'. |

The occurrence of the Cretaceous genus *Protocyathea* in the upper zone (B) either indicates that the beds in question are younger than the Jurassic, or it extends the range of this genus back into that period. If the beds are younger, the Jurassic facies of the vegetation had evidently persisted into the Cretaceous, because several typically Jurassic species of plants are associated with the *Protocyathea*.

The species marked * are the only ones previously recorded from this locality.

## 42. Cuticular studies of Magnoliales.

H. S. Rao, Lucknow.

In the present work the question of the position of the Magnoliales from the point of view of their epidermal features has been taken up. This is rather a new line of inquiry. Florin's criteria viz., the 'Haplocheile' and 'Syndetocheile' types of stomatal development have been made use of. According to this test the Magnoliales are seen to comprise a few synthetic forms, some possessing some Cycadean features, the great majority the Bennettitalean, and a few the haplocheile gymnosperm features.

The aberrant epidermal features of *Euptelea* and *Cercidiphyllum* seem to be correlated with other primitive features of Trochodendraceæ already known.

The view has again been expressed that the progenitors of the angiosperms have to be sought for in that plexus of Gymnosperms which gave

rise to the Bennettitales, the syndetocheile Gnetales, the haplocheile Magnoliales and the majority of the Magnoliales (i.e., syndetocheile) along different lines of descent, ***the last being probably nearest related to the Bennettitales.***

From the point of view of epidermal studies, the Magnoliales do not represent a co-sanguinary group, but indicate a convergence.

# SECTION OF ZOOLOGY

*President*:—G. MATTHAI, M.A., Sc.D., F.L.S., F.R.S.E., F.N.I., I.E.S.

## 1. Evolution of the neuromotor apparatus and the skeletal structures of Trichomonads.

G. C. CHATTERJEE *and* A. N. MITRA, Calcutta.

Neuromotor organelles of Trichomonads originate from already existing ones. This is the usual method already known. Their origin and subsequent development from a cell containing only cytoplasm and nucleus and no other organelles have already been described by the authors in previous papers. In this paper they discuss how this complicated apparatus originates and becomes differentiated into flagella, undulating membrane, axostyle and parabasal, in the light of various views on the subject, specially the binucleate theory of Hartmann, the authors finding support of this binucleate theory in their study of development of the organelles of Trichomonads.

## 2. On a new coccidium *Eimeria koormæ* n. sp. from an Indian tortoise *Lissemys punctata* Smith.

M. DAS-GUPTA, Calcutta.

Thick-walled, unsegmented, fully spherical oocysts were directly recovered from voided fæces and rectal contents of an Indian tortoise *Lissemys punctata*. All the endogenous stages were studied in detail from sections of the intestine stained in iron hæmatoxylin. The mature oocyst marked by a pseudomicropyle measures $14 \times 14\mu$, and oocystic residiuum is absent. The spindle-shaped sporoblast measures $10 \times 4{\cdot}5\mu$, and contains sporocystic residiuum. A differential diagnosis of the known species of *Eimeria* recorded from Chelonia has been shown in tabular form.

The name *Emeria koormæ* n.sp. is proposed for the new coccidium.

## 3. On a new myxosporidian, *Henneguya otolithus* n. sp., a tissue parasite from the bulbus arteriosus of a marine fish, *Otolithus*.

P. N. GANAPATI, Madras.

Two species of a common edible sciænid fish *Otolithus ruber* and *O. maculatus* are found infected by a species of a myxosporidian *Henneguya otolithus* n. sp. The primary site of infection is the muscle and connective tissue of the wall of the bulbus arteriosus where the parasite forms whitish opaque cysts. The vegetative forms or trophozoites show a clear differentiation into an ectoplasm and endoplasm. Two kinds of nuclei, the vegetative and the generative, are present in the earlier stages of the parasite. The propagative stage, or pansporoblasts, originate by divisions of single generative cells. Each pansporoblast gives rise to two spores.

Autogamy is present, and evidence of auto-infection has been seen. The histo-pathological processes are characterized by an increase of blood supply to the infected area which often leads to inflammation.

Fibrosis takes place in the organ, when the fish recovers and degeneration products in the nature of yellow concretions are observed. Infiltration of spores have been noted in inefcted tissues. Isolated spores or groups of them have been located in the kidneys. A periodic variation in the occurrence of infection and the stages of the parasite has been observed. A higher temperature seems to accelerate spore formation.

## 4. Studies on Myxosporidia from fresh-water fishes of Bengal.

M. CHAKRAVARTY, Calcutta.

The author has given a detailed description of six new species of Myxosporidia belonging to the genera *Myxobolus, Ciratomyxa, Henneguya* and *Myxidium,* infecting different tissues and organs of fresh-water fishes.

## 5. Phylogeny and classification of the Sporozoa.

B. L. BHATIA, Punjab.

Sporozoa (*sensu stricto*) comprising Gregarinida, Coccidia and Hæmosporidia, phylogenetically distinct from Amœbosporidia, comprising Cnidosporidia, Sarcosporidia, and Haplosporidia. Chief trends of evolution within both groups. Gametocytes widely separated and produce gametes separately, which would become differentiated; zygote producing a number of sporoblasts, spores and sporozoites (Coccidia) ; or gametocytes associated and encysted together, producing gametes in close proximity which are consequently not differentiated (Gregarinida). Hœmosporidia closely related to Coccidia, but schizogony restricted to one host and sporogony to another. Zygote a motile vermicule which forms an oöcyst which persists only while sporozoites are being produced. Absence of spores with resistant cysts due to the parasite being always sheltered within body of the one or the other host.

Cnidosporidia, Sarcosporidia, and Haplosporidia are best regarded as independent sub-classes, having no affinities with one another or with the Sporozoa (*sensu stricto*).

Minchin regarded the union of the Telosporidia and Neosporidia in one class—the Sporozoa—as a quite artificial arrangement. Logically speaking they should be placed in two distinct classes and named as Sporozoa and Amœbosporidia, but the two classes cannot be regarded as constituting a subphylum, as the first are clearly derived from the Flagellata and the second from the Rhizopoda.

## 6. Indian Sporozoa.

B. L. BHATIA, Punjab.

Brief review of the study of Sporozoa in India. Certain gaps in our knowledge of the group. Some problems for future investigators.

## 7. Some fresh-water sponges from the Dal Lake, Kashmir.

DIWAN ANAND KUMAR, Lahore.

The paper gives an account of a collection of fresh-water sponges made by Dr. Matthai from the Dal Lake. The examination of material has revealed the presence of two genera, viz., *Spongilla* and *Ephydatia*. Each genus is represented by at least one species. A comparison is made with allied species from other localities. These genera have been recorded for the first time from the Dal Lake.

## 8. Studies on the brackish-water anemone *Pelocoetes exul* Annandale, and on *Pelocoetes minima*, a new marine species from Madras.

N. KESAVA PANIKKAR, Madras.

The structure and bionomics of *Pelocoetes exul* and of *Pelocoetes minima* sp. nov. dredged off the Madras coast, have been studied. The differentiation of the column apparent in *P. exul* is absent in *P. minima* ; and the characteristic stinging warts of the former species are unrepresented in *P. minima*. The structure of the stinging warts and groups of nematocysts is described in detail. The cinclides of *P. exul* originate as ectodermal invaginations. The tentacular arrangement is on the same fundamental plan in both the species ; in *P. minima*, however. only four cycles (total 48) of tentacles are observed, while there are normally five cycles (total 96) in *P. exul*. Remnants of an additional cycle are also occasionally present in the latter species. The fourth cycle of microcnemes noticed in *P. exul* is absent in *P. minima*. Sharp differentiation of the mesenteries into microcnemes and macrocnemes exists in both the species. Contrary to the opinion of Annandale and others, the oral disc of *P. exul* (as also that of *P. minima*) has been found to be retractile. Similarly, there is no evidence of hermaphroditism in *P. exul*. It has been found that the sexes are normally separate in this species as in all other species of the Halcampactiidæ. The distribution of cnidæ in the two species has been carefully followed. The acontial nematocysts include both penicilli and spirulæ. The intermediate tracts of the filaments of *P. exul* are peculiar in the possession of spirocysts. The habits and habitats of the two species are described, and the available information on the distribution of Indian Halcampactiidæ is summarized. The morphological peculiarities of the genus *Pelocoetes* and the systematics of the two species are discussed.

## 9. Two new species of blood-flukes belonging to the family Spirorchidæ Stunkard (Trematoda) with comments on the identity of the genera *Plasmiorchia* Mehra, 1934, and *Gomtiotrema* Sinha, 1934, and classification of the family.

H. R. MEHRA, Allahabad.

Two new species of the genus *Learedius* Price, 1934, are described and their relationships with the known species discussed.

The genus *Plasmiorchis* Mehra is identical to the genus *Gomtiotrema* Sinha ; the former name is accepted on the basis of priority.

The genus *Coeuritrema* Mehra syn. *Tremarhynchus* Thapar is not identical to *Hapalorhynchus* Stunkard as held by Price.

The classification of the Spirorchidæ is discussed in the light of several new genera created by Price.

## 10. On a new trematode, *Neoganada bara bankiae*, nov. gen., nov. sp., of the family Plagiorchidæ from the intestine of a fish (*Clarias batrachus*).

J. DAYAL, Lucknow.

A large number of trematodes were collected from the intestine of *Clarias batrachus*.

The new form described in the present communication is related to *Leptophallus* and *Ganada*, but differs from both these in the following characters : the relative size of the two suckers, lobed testes, relative size and position of the cirrus sac and the vesicula seminalis, presence of a receptaculum seminis and yolk sac, distribution of vitelline glands, characters of the uterine coils, and the size of the eggs.

The paper concludes with a short discussion on the relationship of the new form.

## 11. On a new trematode, *Travassosstomum natritis* n.g., n.sp., from the intestine of the Indian river-snake, *Natrix piscator*.

G. D. BHALERAO, Muktesar.

*Travassosstomum natritis* n.g., n.sp., has been described in detail and its affinities discussed. The new genus has been defined and assigned to the new sub-family Travassosstominæ.

Specific diagnosis—*Travassosstomum* : Hind-body four times longer than fore-body. Intestinal cæca extend to one-half to three-fourth of hind-body. Holdfast organ circular. Testes transversely oval. Uterine coils extend from muscular bulb to anterior end of hind-body. Vitelline follicles thick along postero-lateral border of fore-body and over holdfast organ, sparse elsewhere. Eggs measure 0·097 to 0·11 × 0·05 to 0·072 mm.

Diagnosis of *Travassosstomum* n.g.—Travassosstominæ : Body divided into two portions. Holdfast organ almost round, extending posteriorly from Pharynx. Adhesive gland compact, at posterior border of holdfast organ. Testes in anterior half of hind-body, one behind the other. Pars prostatica absent. Ductus ejaculatorius very long. Ovary round, anterior to testes. Receptaculum seminis absent. Laurer's canal present. Vitellaria mainly in anterior part of body. Ductus hermaphroditicus present. Genital aperture ventral subterminal.

Type-species—*T. natritis.*

Diagnosis of *Travassosstominæ* n.sp.—Proterodiplostomidæ : Parasites of snakes. Pseudosuckers and ductus hermaphroditicus present. Ductus hermaphrodicus and the terminal portions of the genital ducts enclosed by a muscular bulb. Pars prostatica absent or rudimentary.

Type genus—*Travassosstomum*, other genus *Proalarioides.*

## 12. The incidence of cestode parasites among ovine hosts in the Punjab.

MOHAMMAD AMIN, Lahore.

Out of a total number of 335 ovines examined for cestodes, 184 were found to harbour the cestode parasites. These parasites occur more abundantly in some localities than in others, the infestation being greater in northern and central districts of the province than in the southern ones. There is, however, a periodicity in the appearance of these worms, the percentage of infection-incidence being highest in July, August and September with a gradual decrease towards January and December. A table, showing the localities of origin and percentages of these infected animals, has been appended.

A certain amount of variation in the occurrence of various genera in different parts of the year, and in animals from different localities, has also been noticed. Tabulated statements showing relative frequency, seasonal variation and geographical distribution (as far as could be ascertained from the locality of the origin of host animals) of various genera met with have been prepared.

## 13. Two new species of *Avitellina* (Cestoda) from ovines in the Punjab.

MOHAMMAD AMIN, Lahore.

In this paper are described two new species of *Avitellina : A. spirillometra* n.sp. and *A. bigemina* n.sp., parasitic in the small intestine of ovines

from the Punjab. The former species differs chiefly from the hitherto known members of the genus *Avitellina* in the convoluted form of the uterus, presence of anteuterine pouch—a structure described for the first time—and in the exceedingly small size of the paruterine organ. *A. bigemina* is distinct from the other species of the same genus in its peculiar bipartite form of the paruterine organ, the complete absence of the intersegmental fibrous pad, and in the size of various structures.

## 14. The occurrence of the cestode, *Helictometra giardi* (Moniez, 1879), in Indian sheep.

MOHAMMAD AMIN, Lahore.

In this paper the author reports the occurrence of *Helictometra giardi* (Moniez, 1879) Baer, 1927, hitherto unknown in Asia, from the intestine of sheep—*Ovis aries*—from the Punjab. The specimens of this species are identical, in general, with those described by previous workers. Certain discrepancies regarding the descriptions of the testes (Stiles and Hassal, 1893), uterus (Baer, 1927) and the genital pore (Moniez, 1871, Blanchard, 1891) are, however, noticeable; these structures have, therefore, been redescribed in the light of observations made by the author.

## 15. On a new nematode *Pseudaspidodera jnanendræ* n.sp. from peafowl *Pavo cristatus*.

G. K. CHAKRAVARTY, Calcutta.

The author examined a collection of worms of the nematode genus *Pseudaspidodera*. Notwithstanding the resemblances his specimens differ from the genotype in many respects, and he has erected a new species to accommodate these worms. In this paper he has dealt with the structural differences and discussed the affinity.

## 16. On the anatomy of *Lingula* sp.

P. R. AWATI *and* G. R. KSHIRSAGAR, Bombay.

The alimentary canal is straight in the anterior portion while it is looped posteriorly. The digestive glands—greenish in colour—are found to open into the stomach by their wide ducts. The circulatory system is very poorly developed, as there is no need for it. Food and oxygen are supplied by the cœlomic fluid. Nephridia are flat tubular structures, each with a nephrostome and a nephridiopore. They act as ducts of the reproductive organs which are lobulated masses. The sexes are distinct. The nervous system is also poorly developed. There are two ganglia—supra-, and sub-œsophageal; nerves to all parts of the body are supplied by these ganglia.

## 17. On the nephridia of *Prionospio cirrifera* Wiren.

R. GOPALA AIYAR, Madras.

*Prionospio cirrifera*, a tiny polychæte, occurs in large numbers in the brackish waters, Adyar. The worm measures 10–12 mm. and has about 50 segments. In segments 5, 6 and 7 there are three pairs of nephridia which are clearly visible through the body wall. All the nephridia are of the drain-pipe type, the lumen being intracellular. There are no nephridia in the middle and the posterior segments. Genital products escape by rupture of the body wall.

## 18. The nephridia of earthworms of the genus *Tonoscolex*.

K. N. Bahl, Lucknow.

In 1919 the author described a new type of excretory system in the Indian earthworm *Pheretima*, the essential feature of which is that the nephridia discharge their excretory fluid into the intestine all along its length instead of on to the surface of the body as in *Lumbricus*. This 'entero-nephric' type of excretory system was discovered later to occur also in earthworms of the genera *Lampito* (*Megascolex*) and *Woodwardiella*. As a result of these studies the author suggested a new classification of nephridia which has been adopted by Stephenson (1930).

In this paper the nephridial system of the genus *Tonoscolex* has been described, and assigned to its proper place in the scheme of classification of the oligochæte nephridia. An account of the blood-supply of the nephridia is also given and the question discussed as to how the classification of nephridia can be used as a basis for the revision of Stephenson's polyphyletic genus *Megascolex*.

## 19. A ciliated apparatus in the larva of *Echiurus*.

P. R. Awati, Bombay.

This is a case of precocious development of a certain adult structure in a larva. In the adult the middle portion of the intestine has its ventral part modified into a separate tube through which fresh water is continually passing towards the posterior end of the animal. This water appears to be useful in aerating the coelomic fluid in which the alimentary canal is suspended.

A tubular and ciliated structure, with possibly a similar function, is found in the larva. It opens at both ends—anteriorly into the larval stomach and posteriorly into the rectum—the middle portion being coiled and slung to the outside of the larval stomach. The tube is double, with cilia in each lumen. There seem to be some valvular structures at either end which allow water to flow in through the rectum into the stomach and *vice versa*.

## 20. The circulatory system in *Thalassema bombayenis* and *Bonellia viridis*.

P. R. Awati, Bombay.

Although the circulatory systems of *Thalassema* and *Bonellia* are similar to each other in general outline there are important differences between them. The ventral vessel which opens at the extreme posterior end into an intestinal sinus surrounding the intestine, is diffuse in *Thalassema*, but distinct in *Bonellia*. At the anterior end, the ventral vessel is continued into the proboscis in which it bifurcates into two branches. In *Thalassema* this anterior part of the vessel is closely attached to the ventral portion of the oesophagus, gizzard and the crop, and is enclosed by two entire sheets of the ventral mesenteries, one on each side of the vessel; in *Bonellia* this portion is entirely free from the oesophagus, etc., and passes between the two anterior setæ. The ventral vessel in *Bonellia* is connected with the intestinal sinus by a single transverse vessel, whilst in *Thalassema* the same is bifurcated at the base, and these two limbs pass, one on each side of the food canal, to the sinus which is very poorly developed. The dorsal vessel seems to emerge from the intestinal sinus at the anterior end; the latter is well developed in *Bonellia* while it is reduced in *Thalassema*.

## 21. On the metamerism of the Indian leech, *Hirudinaria granulosa.*

M. L. BHATIA, Lucknow.

The question of the limits of a somite of the leech has assumed great importance after the appearance of Castle and Moore's view and has led to a good deal of controversy.

According to Whitman the annulus bearing the segmental receptor-organs is the first annulus of a somite ; while Castle and Moore regard the same as the central annulus in a complete somite. An attempt is made in this work to elucidate and support Whitman's limitation of a somite.

The evidence referred to in this paper is derived from the external morphology, internal anatomy, and embryology of *Hirudinaria granulosa.*

## 22. On the structure of the nephridia and 'funnels' of the Indian leech *Hirudinaria*, with remarks on these organs in *Hirudo.*

M. L. BHATIA, Lucknow.

In previous years an account of the nephridial system of the two leeches was given. In this communication the author discusses in greater detail the results of further observation on the following points :—

(*a*) Structure of nephridia in the two leeches.
(*b*) A fully developed 'funnel' (ciliated organ).
(*c*) Connection of these 'funnels' with the nephridia in the adult leech.
(*d*) Embryonic condition of the 'funnel' and
(*e*) Function of the 'funnel' (ciliated organ).

In the embryonic condition, the 'funnel' (ciliated organ) is a solid mass of cells which is distinctly continuous with the nephridium by means of a delicate strand of cells, the initial lobe. The funnel becomes enclosed, at an early stage, in the perinephrostomial sinus, which is a part of the reduced coelom ; this connection of the 'funnel' with the nephridium snaps, and the two become discontinuous and discrete structures.

The 'funnel' is not a degenerate structure ; it has become multiplied into numerous small ciliated funnels which are very effective in their ciliary action.

The central part of the 'funnel' (ciliated organ) is the seat of manufacture of blood-corpuscles which are thrown out into the surrounding sinus by the movements of cilia.

The ciliated organ, instead of serving a renal (excretory) function, has here become subservient to the sinus-system.

## 23. On some leeches from the Dal lake, Kashmir.

M. L. BHATIA, Lucknow.

In September, 1936, Dr. Matthai made a collection of the fauna of Dal lake, Kashmir. It included some leeches also which he very kindly entrusted to me for systematic and morphological study.

They have been identified as follows :—

*Suborder*—Rhynchobdellæ :

Family—Glossiphonidæ :

1. *Glossiphonia complanata.*
2. *Theromyzon* (sp ?)
3. *Hemiclepsis marginata asiatica* Subsp.

*Suborder*—Arhynchobdella.

Family—Erpobdellidæ :

4. *Erpobdella octoculata.*

Some interesting points with regard to the morphology and habits of these leeches are dealt with in the paper.

## 24. Entomostraca of the Dal lake, Kashmir.

G. L. ARORA, Lahore.

The paper contains the results of a systematic and ecological study of the Entomostraca collected from the Dal lake, in September, 1936. Of the twelve species described, three appear to be new to science. The Cladocera are represented by four genera viz. *Simocephalus, Latonopsis, Ceriodaphnia* and *Macrothrix*, the Ostracoda by four genera viz., *Stenocypris, Pionocypris, Eurycypris* and *Cypria*, and the Copepoda by three genera viz., *Diaptomus, Limnocalanus* and *Cyclops.*

## 25. Diseases transmitted by Indian species of ticks in India and other countries and the possibility of their prevention through biological control.

M. SHARIF, Aligarh.

Compared to what is known in other countries about the tick-borne diseases, very little appears to be on record in India. A brief summary of previous work done on this line is given. The writer has tried to show that the tick problem in India is as serious as in the United States of America, where enormous amount of money is being spent upon the control of ticks every year. To give an idea of the extent to which Indian ticks are concerned in the transmission of diseases, the author has listed those Indian species which have been incriminated either in India or in other countries. In man the ticks transmit the causative agents of the relapsing fever almost all over the world, and of the tick typhus fever in India. In domestic animals they transmit diseases caused by *Babesia, Theileria, Spirochæta,* and *Anaplasma* and some of the virus diseases. A suggestion as to the possibility of the control of ticks through the agency of parasitic and predaceous enemies is made.

## 26. Observations on the growth of the green mussel, *Mytilus viridis* L., in the Madras harbour.

M. D. PAUL, Madras.

*Mytilus viridis* L., the green mussel, living in the Madras harbour grows at a very rapid rate and often reaches a size of nearly 100 mm., or 4 inches, in about 16 months. Growth has been found to be continuous and 'annual rings' or 'check marks', which are a result of cessation or reduction of growth during winter in the temperate seas, have not been observed in this form. Methods of studying the rate of growth under natural conditions are described.

This form attains sexual maturity in 48 days after attachment, a fact which is very interesting when compared with *Mytilus edulis* L., which takes nearly a year to mature on the English coast. *M. viridis* probably reaches its maximum size in 2 to 3 years. Intense breeding occurs from March or April to October, but ripe individuals of both sexes can be obtained throughout the year.

## 27. Observations on the growth and habits of *Pyrazus palustris* (Linn.) in the Andamans.

H. SRINIVAS RAO, Calcutta.

The occurrence of *Pyrazus palustris* (Linn.), a gastropod belonging to the family Cerithiidæ, in very large numbers in rock-pools in the neighbourhood of Port Blair gave the author the opportunity to study the growth of this species by the majority-size method. All except the very young individuals below 10 mm. in height which were found in the locality were measured in the course of five months commencing December, 1934. With the measurements of height obtained, a curve is plotted which shows that there are three distinct age-groups represented in the population namely, the 5 mm. group, the 20 mm. group, and the 40 mm. group. These the author believes, represent the broods of three different years. The absence of young individuals below 10 mm. in height during the months December, 1934 to April, 1935, and their occurrence in large numbers in May, 1935, despite the absence of mature females or their eggs in the locality, has led the author to conclude that the area has been colonized by a sudden incursion of veligers from the open sea carried by the tides.

A subsequent measurement of the entire shell population in the same locality in February, 1936, 9 months after the place had been depleted of all the shells above 10 mm. in height, shows that the young shells of the 5 mm. age-group has, during this period reached a stage intermediate between the 5 mm. and the 20 mm. age-groups.

The capacity of individuals of the species to survive adverse conditions in regard to food is inferred from laboratory experiments which are detailed in the present note.

## 28. A preliminary note on the stomach and the probable function of the cæcum of *Pila*.

T. K. GOPALACHARI, Cocanada.

The present note records the ciliary currents in the stomach of *Pila* not recorded so far. It also records two openings of the ducts of the digestive gland in the semilunar pit of the stomach, not one as described by Prashad. Ciliary currents over the ridges and grooves in the semilunar pit carry from these openings fine matter, probably excrement from the digestive glands, to the pyloric chamber along with a copious secretion of mucus. A groove in the pyloric chamber leads through the cæcum into the intestine. The cæcum probably helps in the formation of fæcal pellets.

## 29. A further study of the digestive gland of some Melaniidæ.

R. V. SESHAIYA, Annamalainagar.

This paper discusses the changes noticed in the digestive gland of some Melaniidæ as a result of parasitism by larval trematodes, æstivation, starvation, normal and experimental feeding with different kinds of material. The species employed for investigation are *Melania* (*Radina*) *crenulata* (Desh.), *Melanoides tuberculatus* (Müller), *Melanoides scabra* (Müller) and *Paludomus tanschaurica* (Gmelin). By prolonged feeding with non-digestible material, like finely ground Indian ink, it was possible to induce increased elimination of the material from the digestive gland. This is accompanied by histological changes, chiefly in a marked increase in the number of the secreting cells. The function of the digestive gland is briefly discussed.

## 30. On a new ascidian from Bombay, *Ecteinascidia bombayensis* n.sp.

S. M. DAS, Lucknow.

The author describes a new species of *Ecteinascidia* (*E. bombayensis*, fam. Clavelinidæ) collected from Bombay. This forms a preliminary note for a more extensive report on the ascidians of the Indian coasts. The present species can be distinguished from other existing species by the following characters: the siphonal apertures are 5-lobed; the tentacles are of three lengths and about 64 in number; the posterior dorsal-languets are long, conical and distinct; the transverse muscles completely encircle the pharynx; the internal longitudinal bars bear projections comparable to papillæ; the stomach has folds in its walls. Ten to twelve individuals form a colony, each individual being attached by a peduncle to a basal stolon network. Development is internal, the pharynx acting as a brood-pouch; and the young are discharged into the sea as fully developed tadpoles.

## 31. A case of commensalism between a lamellibranch and a monascidian.

S. M. DAS, Lucknow.

The author describes a case of commensalism between the Indian monascidian *Herdmania pallida* and a lamellibranch *Musculus coenobita*. This association is quite common in the collection made around the South Indian seas. Almost 80% of the monascidians collected by the author had one or more lamellibranchs imbedded in their test. One specimen of *Herdmania* had as many as 40 lamellibranchs of different sizes in its test. They are found more often at the free, than at the fixed, end of the ascidian, and in larger numbers around the branchial, than around the atrial, siphon. Except for a small siphonal cleft, each individual is almost completely imbedded in the test-substance. The author gives a short description of the shell, mantle, byssus, gills, and foot of this lamellibranch.

## 32. On some tunicates from Karachi.

SHADI LALL, Lahore.

The paper deals with the ecology of simple ascidians of the Manora coast, Karachi, and gives an account of two species of the genus *Stylea* from the same locality. *Stylea* is characterized by the presence of simple tentacles, eight folds in the pharynx and by the narrow loop of the intestine. The genitalia consist of a pair of ovaries surrounded by a number of spermaries, and are generally situated on the right. The two species differ from each other in the number of longitudinal bars in each fold and in the number of stigmata in each mesh.

## 33. Observations on the reproductive system, egg case and embryos of *Chiloscyllium griseum* Mull. and Henle.

R. GOPALA AIYAR *and* (MISS) K. P. NALINI, Madras.

A description of the reproductive system of *Chiloscyllium griseum* and its egg case is given. Two embryos, one 30 days old and the other 70 days old, are described. The period of reproduction is rather restricted for tropical conditions and extends from December to April. The time taken for development of the egg into a full-grown embryo is 2½ months. Egg liberation is probably in pairs in quick succession.

## 34. Observations on the structure and function of the nidamental glands of *Chiloscyllium griseum* Müll. and Henle, with a note on the formation of the egg capsule.

(MISS) K. P. NALINI, Madras.

*Chiloscyllium griseum* is a typically oviparous Indian Elasmobranch. The nidamental glands are very prominent and active, and secrete the egg albumen and egg case. They are pear-shaped structures, divided by an incomplete transverse band of parenchymatous vascular tissue, into a cranial and a caudal portion. The cranial region is further differentiated into three parts, an albumen secreting zone, a narrow intermediate mucus secreting portion, and lastly, a cranial shell secreting region. The caudal portion comprises of densely packed shell secreting, as well as mucus, tubules which are very narrow.

All the gland tubules are simple and almost similar in structure consisting of gland cells and ciliated cells. The detailed structure of the different parts of the gland is described. The method of secretion inside the gland tubes and the laying down of the albumen and shell layers are dealt with in detail.

Comparison of the nidamental organs of *Chiloscyllium griseum* with those of *Scyllium canicula* and a few viviparous Madras Elasmobranchs is instituted.

Various views in regard to method of capsule formation are also described.

## 35. Preliminary observations on the structure of the uterus and the placenta in *Scoliodon sorrakowah.*

(MISS) G. MAHADEVAN, Madras.

*Scoliodon sorrakowah* is a common form found in the Madras Coast, and is viviparous. The ovary, in all the specimens examined, consisted of very small ova, even smaller than the ova of frog. Considerable growth of the embryos takes place in the uterus. The walls of the uteri which are at first spongy and thick-walled, become very thin, and lose their elasticity, due to their distension as the embryos grow. The lumen of the uterus is divided into as many compartments as there are embryos, and at the base of each compartment is a trophonemata, a prolongation of the uterine mucosa. This invaginates at its distal end in the form of a cup, into which the yolk sac fits and is almost completely enveloped, thereby forming a yolk sac placenta. As the embryo grows, the yolk sac becomes bigger, and the trophonematous cup less and less concave, till a stage is reached when all connection is completely severed. The yolk sac contains very little yolk and is a round spongy vascular structure. The placental cord is closely beset with appendicula, and their structure has been described. The function of the latter is to absorb nutritive fluid secreted by the inner epithelium of the uterus.

## 36. Notes on the biology of a freshwater grey-mullet, *Mugil corsula* Hamilton, with observations on the probable mode of origin of aerial vision in fishes.

S. L. HORA, Calcutta.

*Mugil corsula* Hamilton mostly lives in freshwaters and has the remarkable habit of swimming near the surface with its eyes prominently projecting out of the water. Observations are recorded on its locomotion, aerial vision, respiration, feeding and breeding. The habits of the species indicate that the fish probably acquired them in the estuaries during the transition period from the marine to the freshwater life. The evolution of the aerial vision in *M. corsula* is attributed to its habit of feeding at

the surface on floating organisms. For this purpose an effort had to be made to raise the ventral mouth to the surface level, with the consequence that a part of the head and the snout was being continually pushed out of the water and thus an inducement was provided for the development of the aerial vision. It is pointed out that terrestrial Gobies, like *Periophthalmus* and *Periophthalmodon*, also acquired aerial vision in the same way as *M. corsula* while still living in water and later took to life on the land.

Reference is made to the remarkable modifications of the eyes in *Anableps*, a cyprinodont of tropical America, and it is indicated that such a structure could not be regarded as the first stage in the evolution of vision in the air. The probable causes that may have influenced the evolution of bifocal vision in *Anableps* are briefly indicated.

## 37. On the bionomics, structure and physiology of certain air-breathing gobies, *Periophthalmus koelreuteri* (Pall.) and *Boleophthalmus boddaerti* (Pall.).

B. K. DAS, Hyderabad (Deccan).

*Periophthalmus* and *Boleophthalmus* have been studied in detail during the months of March, May and June in the backwaters and mud flats of the rivers Adyar and Cooum in Madras. They are to be found in large numbers in the early morning, but after sunrise as the water gets heated the fishes gradually retreat and bury themselves in the cool liquid mud, only occasionally coming to the surface for breathing atmospheric air. *Periophthalmus* is carnivorous, living on crustaceans (Gammaridæ) and insects. *Boleophthalmus* is herbivorous, and lives chiefly on vegetable matter (mostly diatoms) and débris, mixed with small quantity of mud.

Both genera carry on aerial respiration by taking gulps of air, with widely open mouth and bulging their opercular cavities, the latter serving as principal receptacles for air. They also use their gills for breathing, by occasionally dipping their heads and thus moistening the respiratory surfaces. The special character of the opercular chambers and their modifications due to air-breathing habit are discussed. The special type of blood-supply to the organs of aerial respiration is described. The structure and characteristic features of the gills and the secondary branchial folds, as well as those of the mouth-cavity are noted. The view regarding caudal respiration in *Periophthalmus* is rejected.

Behaviour of these fishes has been observed in dry atmosphere, wet grass, mud, atmosphere of $CO_2$ and Chloroform vapour. Effects of injury to opercula and gills have been noted.

Experiments have been carried out with regard to semi-asphyxiation in sea-water and revival period, complete asphyxiation varied under different conditions. Cardiac beats have been carefully noted in the fishes asphyxiated in different media. Causes and nature of adaptations, and the evolution of the air-breathing fishes are discussed.

## 38. On the structure and functions of the so-called Pyloric cæca in two genera of fishes, *Lactarius* and *Osphromenus*.

M. RAHIMULLAH, Hyderabad (Deccan).

In *Lactarius delicatulus* the intestine is simple and short, forming two loops, as is usually the case with carnivorous fish. The stomach is flask-shaped and of moderate size. Cæca are six in number, and are arranged in two groups, four in the right group and two in the left. They vary in length, and when the fish is opened from the ventral side only their distal portions are visible, the proximal ends being hidden by the large liver.

In *Osphromenus gourami* the stomach is of enormous size. The intestine is of considerable length, evidently correlated with a purely herbivorous habit. The cæca are two in number, and are situated one on each side of the stomach. The right cæcum is longer than the left, and usually the proximal half of each is covered over by the liver.

The vascular, and nerve, supplies to the cæca in both *L. delicatulus* and *O. gourami* are discussed.

In *O. gourami* the longitudinal muscle layer is comparatively thin, about ⅙ of the thickness of the circular muscle layer; the latter is not so thick as in most other fishes examined. Submucosa is also relatively thin, and consists of a loose net-work of connective tissue fibres, including a few blood capillaries and cut ends of nerves. Cæcal villi are fairly well developed, and project inwards, about half way across the diameter of the cæcal lumen. There are no cilia on the epithelial cells, and amongst the latter some ovoid mucous-secreting cells also occur. There is no trace of muscularis mucosæ and Brünner's glands, the crypts of Lieberkühn are quite prominent.

In *L. delicatulus* the muscle layers are very thin, especially the longitudinal, and the submucosa is fairly loose. The mucosa is highly developed, including prominent cæcal villi and a large number of more or less round mucous cells. The crypts of Lieberkühn have much wider ducts than in *O. gourami*. Towards the proximal part of the cæcum two or more villi may unite by their free ends, thus forming large intercommunicating passages.

## 39. Sexual dimorphism in *Tetrodon* sp.

D. Waman Bal, Bombay.

There are no definite external characters by which the sexes of this fish can be distinguished. An attempt has, therefore, been made in this paper to establish certain correlations of structures between the two sexes. They are carried out by measurements of the length of the whole body and also of various other parts. It appears from these measurements that the average length of the body and also of the different parts of the fish seem to be greater in the female than in the male.

The material for the present paper was obtained from Bombay docks and was examined in fresh condition.

## 40. On the fishes of the Dal Lake, Kashmir.

Nazir Ahmad, Lahore.

In this paper the author deals with the fishes collected from the Dal Lake during September, 1936. Six species belonging to six genera (*Schizothorax, Orcinus, Labeo, Nemachilus, Botia* and *Cirrhina*) of the family Cyprinidæ and one species of *Exostoma* of the family Siluridæ are represented in the collection. The latter was collected mainly from the Tel Bal Nala which is connected with the lake, while *Nemachilus* was netted both from the Nala and the lake.

## 41. On the development of the vertebral column in *Salamandra salamandra* (Linn.).

H. K. Mookerjee, Calcutta.

Previous workers have stated that the centrum is formed by the bases of the basidorsals in addition to the skeletogenous layer, but actually only the skeletogenous layer aggregates round the notochordal sheaths to form the hour glass shaped centrum on which the basidorsals stand. In the intervertebral region there is only one centre of chondrification instead of a pair of interventrals and interdorsals. This intervertebral cartilaginous ring has been cut by a strand of migratory connective

tissue cells in a cranio caudal direction. A split is formed within the line of migratory cells so as to form a condyle in front and a socket at the back of each centrum, resulting in an opisthocoelous centrum.

Each neural arch in the trunk and tail, has not only a cartilaginous arch in the middle region, as has been described by the previous authors, but in addition, a connective tissue arch on either side of it, which without passing through the stage of chondrification becomes a membrane bone.

Contrary to the previous workers' views regarding the ossification of the cartilaginous arch as such, the cartilaginous arch degenerates. The degeneration of the cartilaginous cells and of inner perichondrial layer of basidorsals take place. So that the adult neural arch of *Salamandra salamandra* is made up of membrane bone the only exception being supradorsal element which becomes a cartilaginous bone and becomes a massive structure.

In the trunk vertebra the hæmal arch as such is not present but there are hæmal arch elements on the two lateral sides of the centrum. A portion of this hæmal arch element is present corresponding to the middle region of the centrum which may be made up of cartilage but in most cases this is also a membrane bone like the membrane bone element of hæmal arch at the anterior and posterior portions of the centrum.

In the vertebra just in front of the pelvic girdle there is a trace of cartilaginous basiventral at the ventral aspect in a paired condition which Goeppert, by mistake, has shown to be present throughout the trunk vertebræ.

In the tail vertebra the condition of the hæmal arches is like that of the neural arch, but the previous workers were of opinion that they have only one cartilaginous arch at the middle of each centrum. The degeneration and the existence of the third piece of cartilage as infraventral are also like the neural arches which nobody has noted previously. The hæmal arch is also made up of membrane bone in the adult condition except the infraventral cartilage.

Rib-bearing process is not formed from the basal stump as upward growth of the hæmal arch as stated by Goette and Goeppert but formed independently and ultimately become joined after coming downwards, with the basal stump. The rib is not a part of the rib bearer but formed in the horizontal septum and ultimately joins with the rib bearer at two points.

## 42. Observation on the course of the facial vein and the formation of the external jugular vein in an American bullfrog *Rana catesbeiana*.

J. L. Bhaduri, Calcutta.

In a previous paper the author established three types of arrangements of the course of the facial vein from examinations of some Indian frogs and toads Unlike the condition found in *Bufo, Hyla* and *Uperodon* (=*Cacopus*) on the one hand and the European frogs (*Rana*) on the other, the facial vein takes a binary course in *Rana catesbeiana*, as is found in a few Indian ranids, one continuing as the cutaneous vein and the other turning back to open into the internal mandibular vein. The author advocates the use of the name facio-mandibular vein for that part which is formed by the union of the facial and the internal mandibular veins.

## 43. Buccal participation in the respiratory mechanism of the Chelonia.

G. P. Gnanamuthu, Madura.

The respiratory mechanism of the chelonia is complicated by the development of the bony carapace and plastron. Several muscles found

in the vicinity of the lungs have been considered to be of respiratory significance, but recently it has been held that the rotation of girdles must be solely responsible. The rôle played by the buccal cavity has been minimized, if not neglected. The author finds the buccal cavity, supported by the hyobranchial skeleton and its muscles, capable of dilation and contraction and thus supplement the action of the thorax in ventilating the lungs.

## 44. The arterial system of the mud turtle, *Lissemys punctata*.

(MISS) B. K. DHILLON, Lahore.

The arterial system of *Lissemys punctata* has been studied by injecting the animal either with aqueous carmine or with gum arabic mass and fixing the animal in rectified spirit.

The heart in *Lissemys* has not the conical shape, which is typical in reptiles. Owing to a peculiar twist to the right of the median plane, the arches and venæ cavæ of the left take a longer course to reach the heart than those on the right. The origin of the subclavians and vertebral arteries is shifted so far forwards that they arise in common with the carotids from the right systemic arch through the innominate. The carotids are comparatively long owing to the elongation of the neck, and give arteries to the vertebral column (cervical region). The internal carotids of the two sides form a loop in the pterygoid through which they pass. Blood is supplied to the alimentary canal by two main vessels which arise from the left systemic arch, instead of from the dorsal aorta. The dorsal region of the vertebral column is supplied anteriorly by vessels from the anterior epigastric and posteriorly by a branch on each side from the sciatic arteries. There is a single pair of urinogenital arteries. Ductus caroticus, ductus Botalli, external carotids, vertebrals and caudal artery are absent.

## 45. Remarks on the exhibition of very young embryos from a tigress (*Panthera tigris tigris*, Linn.), shot in Hyderabad (Deccan).

M. RAHIMULLAH *and* B. K. DAS, Hyderabad (Deccan).

The paper deals with three very young embryos (two males and one female), measuring from 4·2 cms. to 4·4 cms. in length (the tail being about 9 mm. in length). Fore-limbs and hind-limbs, though very small (about 9-10 mm. in length), possess the full complement of fingers and toes respectively, without claws. Eyes, nostrils and mouth are complete, but external ears are in process of formation. The uteri were uninjured, and two embryos were found in the right and one in the left uterus.

From various accounts it appears that breeding in tigers probably takes place all the year round, and that 3 or 4 cubs usually constitute the litter, but even 5 to 7 have been recorded. It would appear that the embryos under investigation might be estimated at 4 to 6 weeks old.

## 46. Chromsomes of the American bullfrog *Rana catesbeiana*.

A. B. MISRA, Benares.

The equatorial plates of the spermatogonia of *Rana catesbeiana* show 26 chromosomes only in the metaphase, the garniture being made up of 14 large and small V's, 8 large and small J's and 4 rod-shaped chromosomes. Thirteen bivalents and thirteen monads are accordingly present in the equatorial plates of the primary and the secondary spermatocytes respectively in their metaphases. This discovery brings the chromosomal complex of *R. catesbeiana* into a line with other species of this

genus which have been karyologically studied and disproves the validity of Swingle's results.

## 47. A preliminary note on the sex-chromosomes of *Paludomus tanschaurica* (Gmelin).

R. V. Seshaiya, Annamalainagar.

The author has made a series of preparations illustrating the spermatogenesis of *Paludomus tanschaurica* (Gmelin). In the formation of the eupyrene sperms, the phases of the first meiotic division show the sex-chromosomes very clearly. In the diploid groups the sex-chromosomes can usually be recognized in the midst of the autosomes. In the first spermatocyte division the X and Y chromosomes show marked precession. The difference in the size of these chromosomes is also very striking, the X-chromosome being larger and curved and the Y-chromosome being in the form of a small round body. The diploid number of chromosomes in the species is 18.

## 48. The yolk-nucleus of Balbiani.

D. R. Bhattacharya *and* M. D. L. Srivastava, Allahabad.

An attempt has been made to summarize the existing knowledge of the origin, structure and functional significance of the yolk-nucleus of Balbiani. The various views with regard to its homology and constitution have been discussed. It has been shown that if we accept the centrosomal nature of the clear vesicles lodged in the centre of the spider 'Dotterkern', and the mitochondrial character of the enclosing lamellæ, the difficulties surrounding the task of homologizing the typical spider yolk-nucleus of Van Wittich and others with those reported from the eggs of other classes of animals—vertebrates and invertebrates—are solved to a great extent. The yolk-nucleus then can be defined simply as the centrosomal area of the oocyte carrying on accumulation of mitochondria and other cytoplasmic components. The grounds on which the central vesicle can be accepted as the homologue of the somatic centrosome (Balbiani) and the lamellæ as the modified mitochondria have been briefly discussed, and attention has been directed towards the necessity of further research on the subject.

## 49. Studies on the structure of the golgi apparatus. IV. Endostyle of *Branchiostoma indicum* (Willey).

M. K. Subramaniam, Madras.

An analysis of the previous literature on the Golgi apparatus shows that views regarding the existence of a network in vertebrates had changed from time to time. A list of representative tissues where a Golgi apparatus is recorded in vertebrates is given. A perusal of the list shows that a network does not occur in all tissues. Neither can a 'Golgi zone' be postulated. The terminology and the conceptions of the shape and structure of the Golgi apparatus are so confusing that an attempt has been made to clarify some of the issues. Though the analysis was made in order to see whether a clue might be available as to the probable mode of attack of the problem of the evolution of the network like Golgi apparatus, the accumulated knowledge regarding the Golgi apparatus does not enable one to select any particular animal or tissue where such evidence may be expected. The study of *Branchiostoma* was undertaken under the belief that some clue regarding the evolution of the network may be found. No such evidence, however, was actually obtained.

Each group of mucus secreting cells seems to be in a particular stage of secretory activity. The variations in activity between the individual cells in a particular group is very small. It is generally observed that while two groups of gland cells are loaded with mucus, the other two are at the beginning of the secretory cycle.

The mitochondria which appear as a few large grains in the cells at the beginning of the secretory activity breaks up into small granules before mucus droplets put in their appearance. Most of these mitochondrial granules are extruded with the mucus droplets.

The Golgi apparatus occurs as a few small grains having an indefinite distribution. There is no 'Golgi zone' and neither are these elements collected around a centriole. These elements increase in size and number and as they do so, in many of them the central area becomes brownish. The elements finally get scattered through the cell. This scattering is soon followed by the appearance of mucus in the chromophobic areas of the Golgi elements. Increase in size of the secretion droplets leads to rupture of the chromophilic portion in regions where it is thin and the mucus globules with Golgi caps may be seen in the cytoplasm. Most of the Golgi elements degenerate and those left behind apparently reorganize for the next secretory cycle.

The recent work of Hirsch and Duthie are discussed and it is shown that unless equal importance is given in future studies to the shape and structure of the Golgi apparatus and mitochondria as is at present given to the function of these cytoplasmic components we cannot accept the claims put forward by the above workers. There appear to be exceptions as such, critical evidence is necessary.

## 50. The spermatogenesis of *Clibanarius padavensis.*

(MISS) C. K. RATNAVATHI, Madras.

The testes of *Clibanarius padavensis* present the seminal elements in various stages of growth, primary and secondary spermatogonia and spermatocytes, spermatids as well as fully mature sperms being recognizable in their testicular tubules. The spermatogonial number of chromosomes is hundred and sixteen. A centrosome, chromatoid bodies, golgi and mitochondria are present in the cytoplasm. The first spermatocyte division is reductional. The spermatid has a spherical, granular nucleus to begin with but with the transformation of the spermatid it becomes vesicular. The golgi bodies fuse to form an acroblast and this secretes a ring-like acrosome which later fuses with the rim of the nucleus which has by now become cup-shaped. The mitochondria fuse to form a vesicle which settles in the cup of the nucleus. The centrosome divides into two, and one of them settles in the centre of the nuclear cup while the other forms a ring-like structure at the distal end of the mitochondrial vesicle. The central body grows out from the proximal centrosome and extends to the distal centrosomal ring. Six tufts of spines now grow out from the cytoplasm surrounding the nucleus and the formation of the sperm is completed. The sperms get enveloped in spermatophores as they pass down the deferent duct and explode in a characteristic manner when placed in dilute salt solutions.

## 51. Spermatogenesis in the common Indian pigeon *Columba livia domestica.*

S. N. MEHROTRA, Benares.

The Golgi bodies of the spermatocytes, along with the idioplasm, coalesce to form a definite mass in the spermatid which establishes itself at an appropriate place against the nucleus to give rise to the acrosome. The nucleus, during spermateleosis, elongates both in the direction of the acrosome granule and the centriole. Mitochondria, which lay scattered

in the cytoplasm of the spermatogonia and the spermatocytes, then become plastered round the fibril which develops between the proximal and the distal centrioles. This mitochondrial cluster eventually gives rise to the middle piece of the spermatozoon, the proximal centriole forming the neck. The flagellum of the spermatozoon is formed from the free portion of the axial filament of the spermatid. Lastly, the sloughing off takes place after which the spermatozoa mature. Heads of the immature spermatozoa show a complex network, or spirals, of chromatin in their interior. Such a structure has been reported by Wilson in the case of *Gallus*, and by Guyer in the case of *Columba*. The structure, distribution, and behaviour of the cells of Sertoli have also been described, and the differences between the mature and the immature spermatozoa indicated.

## 52. The decapod sperm.

VISHWA NATH, Lahore.

In 1932 (*Quart. J. Micr. Sci.*) the author gave an account of the structure and transformation of the spermatid into the spermatozoon in the brachyuran fresh-water crab, *Paratelphusa spinigera*. The homologies of various weird structures described by earlier workers were worked out in the light of modern literature, and it was made clear that the crab sperm, in spite of its fantastic form, is with respect to its components exactly like a typical sperm. In 1937 (*J. Morph.*) the author showed that the sperm of the macruran, *Palæmon lamarrei*, on the contrary, presents some atypical features.

A detailed study of the spermatogenesis of the hermit-crabs *Coenobita rugosus* and *Clibanarius longitarsus* made at Krusadai during the summer of 1937 has brought out several interesting and atypical features: (1) the Golgi material degenerates during spermateleosis, as in *Palæmon lamarrei*, and consequently the acrosome is conspicuous by its absence, (2) there is differentiated in the axial region of the cytoplasmic vesicle, which is of mitochondrial origin, a chitinoid tube, in which the enlarged centrosome is safely lodged, (3) the formation of the chitinoid tube seems to be associated with the fact that the centrosome remains single and does not perform the plugging function, so conspicuous in *Paratelphusa* and *Palæmon*, (4) the spines are, as in *Palæmon lamarrei*, cytoplasmic in origin and spring up from the region of the centrosome, but in *Clibanarius longitarsus* there is evidence pointing towards the conclusion that the spines are in reality bundles of axial filaments, (5) on two occasions the sperms of *Coenobita rugosus* were noticed to perform slow movements, using the spines as fulcra.

# SECTION OF ENTOMOLOGY

*President* :—MOHAMAD AFZAL HUSAIN, M.A., M.Sc., F.N.I.

## General

### 1. Amplification of the theory of multi-phased gastrulation among insects, with remarks as to its applicability to other arthropods.

M. L. ROONWAL, Pasni (Baluchistan Coast).

None of the explanations, which have been offered so far, is completely satisfactory in explaining the mode of endoderm formation in the class Insecta satisfying the general tenets of the germ layer theory. The author (*Phil. Trans. Roy. Soc. Lond.*, B., Vol. 226, 1936) proposed a theory of multi-phased gastrulation. Insect gastrulation occurs not in one or two phases, but in several. The insectan endoderm is divided into primary and secondary portions. The yolk cells are undoubtedly endodermal. The theory was first suggested in relation to *Locusta* where four gastrulation phases were recognized. The occurrence of supernumerary ventral (gastral) grooves, the yolk cell membrane, etc. present in other insects support the theory. With some amplification the theory is universally applicable to the class Insecta. Three main phases and several sub-phases of the first and second order have now been recognized. Further, not only the endoderm, but also the ectoderm and the mesoderm, are regarded as having undergone a quadruple division thus: Firstly, into primary and secondary portions; secondly, each of these become sub-divided into permanent and evanescent portions. Each gastrulation phase involves various modes for its being brought about. Of these, emboly or invagination, when it occurs, is not the most important and is a secondary feature. The insectan gastral groove is, therefore, not homologous with but analogous to the blastopore of the annelids.

There is considerable evidence which suggests that the theory of multi-phased gastrulation in its fundamental aspect, viz., the prolongation of the gastrulation act, is applicable to the Arthropoda in general and to the Myriapoda and Crustacea in particular. However, the number and nature of the various phases and sub-phases in these groups differ somewhat from those in insects. Thus, the first phase of insects is probably absent in the Crustacea.

### 2. Some reversal changes among locusts and other Acrididae, and the probable importance of the third instar.

M. L. ROONWAL, Pasni (Baluchistan Coast).

In the Acridiidae there is, in general, a progressive change of either increase or decrease of various characters with each instar, the direction of the change remaining constant from the first to the final instars. Recently, however, some data has accumulated which shows that, among locusts and other Acridiidae, certain peculiar changes—morphological, physiological as well as in behaviour—take place when the hoppers go from the third into the fourth instar, and in one instance, from the second into the third. These are mostly reversal changes and affect the direction of the dorsal spot of eye, the position of wing and elytron rudiments,

the growth coefficients of various body parts, the respiratory intensity and, finally, the locomotor activity. Extra moulting, on the other hand, is a third instar. A partial explanation is suggested. Their biological significance, however, still remains obscure.

It is suggested that these changes are governed by an automatic regulation the mechanism of which is released, as a rule, in the later part of the third instar. Available evidence suggests there types of such regulation, viz., physiological regulation influenced by external environment, physiological regulation not so influenced and, finally, general regulation not influenced by external environment. Since the majority of these changes occur when the hopper goes from the third into the fourth instar, the third instar is considered as unusually important.

## 3. A preliminary note on the probable existence of seasonal migration among the solitary phase individuals of *Locusta migratoria* in North-West India.

Y. Ramachandra Rao *and* D. R. Bhatia, Karachi.

There is sufficient evidence to show that solitary individuals of *Schistocerca* are capable of making long distance migrations with the seasonal change of rain-belts, from the winter rain regions of Baluchistan to the summer rainfall areas of the Indian Desert at the beginning of summer, and at the close of summer breeding, back to the winter rain areas of Baluchistan in autumn and winter.

In the course of Desert locust survey, specimens of the solitary phase of two other locusts—*Locusta migratoria* and *Patanga succincta*—have been met with.

The analogy of *Schistocerca gregaria* suggested a similar migration in the case of these two locusts. The data available for *Patanga* are, however, too scanty for drawing any definite deductions, but in the case of *Locusta*, fairly significant, though fragmentary, information has been gathered.

It seems that the solitary individuals of *Locusta* breed in spring in Baluchistan areas and migrate at the beginning of summer into the Desert areas, where a summer generation is produced, which apparently migrates westward in autumn.

Since both *Schistocerca* and *Locusta* very often appear and disappear together in the Sind-Rajputana areas, it is presumed that the same meteorological factors—such as the development of areas of low saturation deficiency and the seasonal change in the wind-directions—affect the migration of both species.

During 1937 fairly intensive breeding of *Locusta* would appear to have occurred in the Bolan, Kohlu and other valleys of Baluchistan in May-June, and the occurrence of large concentrations of *Locusta* noticed in July at Sadulpur and Nohar in east Bikaner may possibly have to be linked with the spring breeding in Baluchistan.

## 4. Copulation and allied phenomena in the Desert Locust (*Schistocerca gregaria*, Forsk.).

C. B. Mathur, Lyallpur.

The behaviour of the sexually mature adults, before, during and at the end of copulation has been described. The normally very 'shy' locust is much less so when in coitus. Disturbing circumstances, such as thunder, light rain, and wind are not sufficient to force a copulating pair to break. The female, with the male on her back moves away to a place of safety.

A female plays a more or less passive part in mating, and for duration and frequency of copulation the male is entirely responsible.

The time required for the formation and transference of a spermatophore from male to female is about half an hour. A copulation of a shorter duration than this is ' false ', in the sense that the female receives no fertilizing fluid.

At the time of the first copulation the male is sexually fully mature while the female may not have reached the stage of full maturity. Mating hastens the sexual maturation of the female.

Parthenogenesis occurs, but in females which have not mated oviposition is rare and belated. Pospelov's assumption that the penetration of fertilizing fluid is necessary for sexual maturation is not well founded. Even desexualized males and females mate. A female mating with a desexualized male oviposits as early and as frequently as a female mating with a normal male.

## Taxonomy

### 5. A proposed revision of the present taxonomy and nomenclature of the Indian honey bees.

T. V. Ramakrishan Ayyar, Madras.

Forty years have now passed since Col. Bingham published an account of the Indian wasps and bees (Hymenoptera) (Vol. I—*Fauna of British India series* 1897) and, since then our knowledge of these insects, especially regarding their classification, has undergone revolutionary change. It will be an extremely valuable contribution to Indian Entomology if a revision of Bingham's volume is undertaken. Since 1897 hundreds of new species have been recorded from different parts of India. By 1916-17 when the present writer published the ' Catalogue of new wasps and bees recorded from India since 1897 ' in the Bombay Natural History Journal, over two hundred new species had been recorded. In this paper a suggestion to revise the taxonomy of the honey bees of India is made. A proposal is put forward to erect a new Sub-genus : *Megapis* to include the rock bee—*Apis dorsata*, because it possesses striking features of its own. A proper identification of the South Indian Dammar-bee (*Melipona*) is also attempted.

### 6. On two Chalcidoid parasites on moths with a description of *Eupelmus terminaliæ*, sp. nov.

H. A. Hafiz, Calcutta.

The occurrence of two Chalcidoids, *Brachymeria euploeoe* (Westw.) and a new species of *Eupelmus* found as parasites of moths is recorded in this paper. A detailed description of the male and the female of the new species is also appended.

### 7. Some species of the Scolytidae (Coleoptera) from Mysore, with special references to the occurrence of *Stephanoderes hampei* Ferr, in dry cotton fruit stalks and carpels.

T. V. Subramanian, Bangalore.

Extensive collections of scolytid beetles were made in the coffee estates in Mysore and Coorg, when a search was instituted in 1930 for the coffee berry borer *S. hampei* Ferr. Out of the 12 different species collected four are new to science.

No *Stephanoderes hampei* was found in any of the estates. Specimens of *Stephanoderes hampei* were collected on the dry fruit stalk and empty carpels of cotton in a place far remote from the nearest coffee area.

Further examination of cotton fruit stalks and carpels from different parts of the State did not reveal the presence of the coffee berry borer

*S. hampei*, but all stages of three different species of the genus were obtained and these are :

*Stephanaderes uniseriatus*, Eggers.
*Stephanaderes eupolyphagus*.
*Stephanaderes arecaae, Hornung*.

As three different species of *Stephanoderes* are quite common on dry cotton stalks and carpels and the fourth one *S. hampei* was obtained once, it is very likely that further search will reveal the presence of this insect on this new host plant, the other host plants of the insect recorded in foreign countries being *Coffea schumanniana*, *Tephrosia*, *Crotolaria*.

## Morphology

### 8. The mechanism of oviposition in the Ak-grasshopper (*Poecilocerus pictus*).

S. S. KAPUR, Lahore.

A brief account of the morphology of the exposed parts of the ovipositor of the Ak-grasshopper (*Poecilocerus pictus*) is given. The muscles employed in the mechanism of digging and egg-laying, i.e. in *exsertion* and *retraction* of the ovipositor and *opening* and *closing* of the valulae are described.

### 9. On the post-embryonic development of eye-stripes and their correlation with the number of larval instars in the life-cycle of *Schistocerca gregaria* Forsk.

S. MUKERJI, Karachi.

The paper embodies the observations made during the study of the post-embryonic development of stripes in the compound eyes of *Schistocerca gregaria*, and delineates its correlation with the number of larval instars in the life-cycle of this species. Thus, it has been found that 4 different types of eyes viz., with 5, 6, 7 and 8 stripes are to be recognized in *Schistocerca gregaria*, correlated as they are with 4, 5, 6 and 7 larval instars in the different types of life-cycle.

On the basis of the experimental results obtained in the case of *Schistocerca gregaria*, the author is tentatively of opinion that the same relationship exists between eye-stripes and the number of larval instars in other Acridids with difinite eye-stripes.

Further, it has been maintained that this variation in the number of instars in the life-cycle of the same species is neither a transmissible hereditary character nor is related in any way with sex, as has been considered by some authors. It has also been found to be independent of the following factors, viz. food, relative-humidity (atmospheric) and sunshine. It is suggested that the crowding of hoppers in a limited space may possibly have some effect on the inhibition of certain instars.

### 10. Correlation of eye-stripes, with instars of *Schistocerca gregaria* Forsk.

R. N. BATRA, Sindh.

One hundred and fourteen isolated hoppers of *Schistocerca gregaria* Forsk were fed on differed food plants to discover if the number of stripes in the compound eyes of the adults could be correlated with the quality of food given to the hoppers during their post-embryonic development. The results obtained indicate that the number of eye-stripes is entirely

dependent on the number of moults, a hopper undergoes during its development, but is independent of the quality of food. It is also seen that in case of seven-striped adults it is always the second moult which is repeated and that both males and females with seven stripes are produced.

## 11. An extra hopper stage in the Desert Locust (*Schistocerca gregaria*, Forsk.).

C. B. Mathur, Lyallpur.

The Desert Locust usually passes through five hopper stages, not considering the vermiform larva. Sometimes an additional hopper stage occurs. This is always after the normal third stage. A hopper in extra third stage is bigger than a third stage hopper but smaller than a normal fourth stage hopper. It lies between the two normal stages in respect to the size and disposition of the wing pads, but the number of their antennal segments and the number of stripes of eyes corresponds to those of a normal fourth stage hopper. Hoppers of advanced stages and adults which have passed through the extra stage are recognizable by the additional antennal segments and eye stripe which they bear.

In a typically gregarious brood the extra stage does not occur. In the transient forms it occurs only rarely. It is characteristic of phase *solitaria* and possibly occurs to accommodate the greater growth, resulting in bigger size which *solitaria* Desert Locust attain.

## 12. On the thoracic mechanism of the pulse beetle *Bruchus quadrimaculatus* Fabr.

Durgadas Mukerji, Calcutta.

This paper is one of the series on the pulse beetle and deals with the structure of the thorax and its musculatures. The meso- and metathorax are divisible into prescutum, scutum and scutellum. The first and last constituent parts, represent pro- and mesophragmata respectively. The musculature of the wings as well as of the legs are described. The peculiarity of the flexor and extensor muscles of the wings is shown. The rotatory muscle of the third leg which shows a rotatory motion along the transverse axis is described.

## 13. The alimentary canal of *Coccinella septempunctata* (Coleoptera) with some observations regarding the re-association of malpighian tubules.

S. Pardhan, Lucknow.

This paper embodies, firstly, a histological study of the alimentary canal, specially the mid-gut of *C. septempunctata*, and secondly, a few experiments throwing considerable light on the problem of re-association of the malpighian tubules with the hind-gut.

The histological study of the mid-gut has revealed *four* definite types of epithelium one of which is surprisingly peculiar and has not been described before. This type of epithelium is peculiar in showing apparently two layers of cells one superimposed over the other, the outer layer having large, regularly arranged, inter-cellular vacuoles as have not been described before at least in the gut of insects.

In Coccinellids as well as in many other insects the malpighian tubules after originating at the junction of the mid and the hind-guts and then traversing into the body cavity re-associate with the posterior portion of the hind-gut. The significance of this re-association has remained a mystery ever since 1811 when such an arrangement was first described although several theories have been put forth, the latest of them being that of Landis (1936). The experiments described in this paper prove

contrary to all previous theories, that the re-association of the malpighian tubules is a part of the device for the conservation of water. The re-associated portions of the malpighian tubules act as a filter for eliminating waste toxic material contained in the liquid which is mechanically pressed out of the colon into the body-cavity.

## 14. On the structure of the so-called 'penis' of the Oriental cat-flea, *Ctenocephalides felis* subsp. *orientis* (Jordan).

M. SHARIF, Aligarh.

The complicated apparatus forming the so-called 'penis' of the cat-flea comprises, as in other insects, of two distinct types of structures; the phallic organs consisting of a median intromittent organ, the aedeagus and its supporting structures, and the periphallic organs which assist in copulation by clasping the female.

The phallic organs are sunk into a large genital chamber which is a permanent irreversible pit and its outer terminal portion is narrowed to form a highly sclerotized and complicated structure. The phallus is short and is about one-half the length of the genital chamber. As it cannot protrude through the narrow external opening of the genital chamber, the sperm fluid is carried into the vagina by two apodemes which in reality form the true copulatory organ. Enclosed within the dorsal portion of the periphallic organs is an elastic sac leading by a narrow canal into the terminal portion of the genital chamber, which acts as a pumping organ.

The periphallic organs consist of two strongly developed sclerites which give support to the genital chamber and the genital pouch, and the musculature of the organ. Their structure and homologies are described in detail.

# Physiology

## 15. Effect of different sugars on the longevity of *Microbracon greeni*, Ashm.

S. N. GUPTA, Namkum.

The problem was initiated by Dr. H. K. Sen, who suggested that the study of carbon assimilation might be useful in determining the conditions necessary for the healthy growth of this braconid. Arabinose (Pentose), glucose (Hexose) and canesugar (Hexodiose) were selected for study.

Arabinose 1 per cent. solution was found to be the most inferior of the three sugars. Adults fed on cane-sugar were found to live longer than those fed on other sugars. Feeding on 3 per cent. solution both in the case of glucose and cane-sugar resulted in longer longevity than on 1 per cent. solution.

## 16. Further observations on the rôle of blood in ovulation in Culicidæ.

S. K. SEN, Muktesar.

These observations, which are in continuation with those previously published by the author (1917, 1923), were carried out to determine the relative influence of whole (shed) blood, serum and other blood constituents on the maturation of ova in *Aëdes* (*Stegomyia*) *albopictus* Skuse. Viable eggs were deposited by these mosquitoes when they were fed either on whole blood or on serum, but their number was considerably less than in the case of those fed in the normal manner on the body of a mammalian host.

No eggs were obtained when the mosquitoes were fed on physiological (Ringer-Tyrode) saline solution or on water with a pH value approximating that of serum. The results of providing a physical stimulus in the form of liquid food heated to 37°C. were likewise negative. A proportion of the mosquitoes used in each experiment were periodically dissected out and their ovaries examined, but no indication of ovulation was obtained in individuals other than those fed on whole blood or serum.

The paper describes a convenient technique for feeding mosquitoes artificially in captivity.

## Ecology

### 17. On some physico-chemical factors of the breeding places of *Anopheles sundaicus*.

P. Sen, Calcutta.

The paper deals with the three factors—chloride, hydrogen ion concentration and carbonates of natural waters of the Salt Lake areas to the east of Calcutta as well as in Calcutta itself in which *Anopheles sundaicus* (*ludlowii*) breeds. Only such samples in which breeding was actually going on the days of analysis were considered. It was found that the salinity as expressed in terms of chlorine varied from 634·0 to 16·0 parts per 100,000 and the average was 164·3. The variation was so great that this factor by itself cannot be utilized to predict *sundaicus* breeding areas. The pH value was more constant for the breeding water ranging between 7·7 to 8·5, the average being 8·2. The figures for carbonates were irregular and showed no relationship with pH. Presence of algæ of the genera *Enteromorpha*, *Oscillatoria*, and *Oedogonium*, as also the weed *Hydrilla* were found to be the essential factor—which factor along with pH probably determines the presence or absence of *Anopheles sundaicus* in a water collection.

### 18. Length of life of pink bollworm moth and its correlation with temperature and humidity.

H. D. Nangpal *and* V. N. Poorna Pregna, Hyderabad (Deccan).

The pink bollworm moths are relatively long lived at Parbhani. To discover the reason for this, a statistical study of the longevity of the 'short cycle' moths, in relation to temperature and humidity was undertaken. Scatter diagrams for longevity in relation to humidity, temperature, and temperature and humidity showed that the whole period—15th June to 15th April—could be divided into two separate periods: the first ending with 30th November. It was observed that the average longevity of moths in the first period was one and a half times that in the second period, and while the average daily mean temperature was practically the same for the two periods; the humidity was higher by about 50 per cent. in the first period. The coefficients of correlation were worked for all the factors and for the two different periods separately. It was found that in the first period, life was negatively correlated with temperature or humidity. In the second period the correlation was negative with temperature and positive with humidity. Multiple correlation coefficients and the corresponding regression equations for length of life in terms of humidity and temperature were also worked for the two periods. Mean humidity between 60 per cent. and 70 per cent. with mean temperature varying from 60°F. to 70°F. was found to be suitable for the long life of the moth.

## 19. Effect of temperature and humidity on the mortality of the silkworm, *Bombyx mori* L.

D. P. Raichoudhury *and* D. C. Sarker, Calcutta.

Two generations of silkworms were reared under ordinary laboratory conditions. These were the progeny of an apparently healthy female. The first generation reared in March, 1937, behaved normally and was found to be apparently healthy. No symptoms of any disease were noticed. Neither the temperature nor the humidity was high in this month.

The second generation reared in April, 1937, was quite healthy and behaved like normal worms till the onset of the 4th moult; but after this moult, when both temperature and humidity rose fairly high, i.e. 94°F. and 87 per cent., a heavy mortality (85% approximately) occurred. Death was mostly due to Flacherie and Grasserie. This experiment confirms the view expressed by Jameson that 'When both temperature and humidity are high then Flacherie is to be expected'. Mortality ratio does not become so high by variation of a single factor.

## 20. Ecological study of soil organisms in the sterilized soils at Rothamstead.

K. D. Baweja, Lyallpur.

Soil was sterilized to a depth of one foot in February and May, 1936, by baking it at 212°F. Some plots were barricaded by iron sheets 12 inches below and 6 inches above ground and other left unenclosed. Samples were taken at fortnightly intervals throughout a sequence of 14 months. Ladell's flotation method was used for isolating soil organisms. (1) The soil organisms took seven months in the unenclosed and five months in the enclosed plots to reach normal density. At the close of the experiments the number on the sterilized plots had increased to 1·5 and 1·8 times that of control. (2) The relative proportion of the soil organisms was considerably affected. Some predominating forms having failed to maintain their dominance in the sterilized plots, some rare ones increased enormously. (3) Distinct seasonal variations were another feature of the fauna, particularly Collembola. (4) Certain injurious families of Collembola increased from 1·5 to 22 times over the control.

As the soil under tropical conditions gets partially sterilized during summer, it is quite possible that the 'Root rot' of cotton and other plants, like the 'Root rot' of sugar-cane in Louisiana, may be found to originate from the direct damage caused to the tender roots of young plants by the vast number of these small animals.

## 21. The influence of temperature on the rate of growth and size in the desert locust (*Schistocerca gregaria* Forsk.).

Abdul Haq, Lyallpur.

The rate of growth of the locust hoppers expressed as a correlation between their initial weight (at the time of hatching) and their final weight (just after acquiring wings) was studied at 27°, 33°, 37° and 40°C. respectively. It has been found to vary in inverse proportion to temperature.

Temperature also influences the size of the adult. Adults developing from the hoppers belonging to the same hatching, but bred at 27° and 40°C. showed difference in size. Individuals reared at 27°C. were bigger in size than those reared at 40°C. The locusts at the two temperatures were of the same phase (having been reared singly) but had different body proportions, suggesting that the body proportions depend on the size of the individual.

22. The effect of climatic factors on the flea *Xenopsylla cheopis.*

P. A. BUXTON, London.

## Insect Behaviour

23. The frightening attitude of a desertmantid, *Eremiaphila braueri*, Kr.

M. L. ROONWAL, Pasni (Baluchistan Coast).

*Eremiaphila braueri*, Kr. has been observed to assume a peculiar frightening attitude when pursued by an enemy. After running away a short distance, it suddenly turns round, unfolds its wings and stands erect on its hind legs, ready to peck if the enemy approaches too close. If the enemy moves round, the mantid also moves and always tries to face his adversary. This may last for twenty minutes, or even more. This attitude perhaps frightens away the enemies which are usually lizards and probably also birds. The mantid is generally found on hard clayey and 'kallar' soils, in preference to sandy areas locally known as 'reks', and is protectively coloured, being a dull greyish brown. The lower surface of the elytra and both the surfaces of the hind-wings, which are non-functional for flight, are brightly coloured, being of a dark purple hue almost tending to black. They play an important rôle in the frightening attitude. So far, only ripe females have been observed to assume this attitude, unripe females and males not having been met with in the field. As shown by an examination of the stomach contents, the main food of the mantid appears to be desert ants.

24. Studies in the phototropic response of the larvæ of *Trogoderma khapra* Arr.

GURCHARN SINGH, Lyallpur.

Reactions of *Trogoderma khapra* larvæ to artificial light were studied. It was observed that the newly hatched larvæ showed complete indifference to light but as they grew older, they gradually developed negative phototropism, with the result that on the third day after hatching 77 per cent. of the larvæ showed distinct negative phototropism. This response became much more pronounced during the subsequent instars. A few larvæ, however, remained indifferent to light and the number of such individuals decreased markedly as the larvæ developed. Further some of the larvæ before and after a moult became indifferent to light. With the approach of the pupal instar the majority of the larvæ became indifferent once again.

## Bionomics

25. Life-history and biology of *Monophlebus stebbingi.*

A. B. MISRA *and* S. R. M. RAO, Benares.

Copulation in *Monophlebus stebbingi* takes place in the third week of May, after which the females begin to retire for oviposition in suitable places and this continues till the end of July. The ovary is very rudimentary at that time and it takes five months to attain maximum development. Eggs are laid in ovisacs specially secreted for the purpose. The eggs require five to six months for incubation. The first stage nymph appears by the end of March. The sex of the nymphs can be distinguished by the colour differences the male-producing larvæ being pink coloured, the female producing ones being yellow. The nymphs

of the two sexes differ in their behaviour also, inasmuch as the male nymphs retire to suitable places for the purpose of pupation, while the females remain on the branches. The duration of the second stage larvæ is 11 to 12 days. Soon after the second moult, the male nymphs lie inside the last nymphal skin and undergo a process of metamorphosis. The male moults four times, and the females three times only. The third stage of the females lasts for 16 to 18 days. The process of copulation is described.

## 26. On the habits and life-history of *Amphipsyche indica* Martynov. (Trichoptera).

H. A. Hafiz, Calcutta.

A short account of the life-history of a trichopteran *Amphipsyche indica* Martynov is given. The larval and pupal stages of the insect were described by the author in a recent paper, and the present account completes the account of the life-history of this form.

## 27. Two caterpillars of economic importance not recorded before in S. India.

T. V. Ramakrishna Ayyar, Madras.

At the previous session of the Congress the author submitted a paper on the cultivation of the Koorkan (*Coleus parviflora*), as a vegetable crop in the Malabar, and a passing reference was made to two leaf eating caterpillars causing some damage to the crop. The insects have been identified as *Pycnarmon cribrata*, F. and *Phostria piasusalis*, W.—(*Pyralidae*).

The *Pycnarmon cribrata* is badly parasitized by *Microgaster psarae* W. (Braconidae).

Observations on the bionomics of these insects have been made. There is no previous record of these insects from South India.

## 28. *Lithocolletis virgulata*, Meyr.

Hari Dev, Lyallpur.

*Lithocolletis virgulata*, Meyr., is widely distributed in the Punjab. Its caterpillar mines the leaves of *Pongammia glabra*, Vent., *Butea frondosa*, Koenig, etc.

Eggs are inserted singly, usually on the upper side of the leaf in summer and on its both sides in winter. A female lays up to 20 eggs. The eggs hatch out in 3-4 days in summer and 16–25 days in winter. The larval stage lasting for 12–14 days in summer and about 42 days in winter. Pupal stage lasts for 2 to 15 days, pupation taking place in the mine.

## 29. The economic rôle of South Indian horn worms (Sphingidae).

T. V. Ramakrishna Ayyar, Madras.

This paper is an attempt to bring together our knowledge of the bionomics of South Indian Sphingids of economic importance.

## 30. The high fecundity of the Epilachna beetles *Epilachna vigintiopunctata* Fabr, and *Epilachna dvdeeastigma* Mul., in Cochin.

C. S. Venketasubban *and* Neelakanta Iyer, Trichur.

While studying the bionomics of these two Epilachna beetles in June, July, 1933, it was found that they possessed high egg laying capacities.

Tabular details are given of the extent of oviposition of five females of *Epilachna vigintiopunctata*. It was noticed that during a period of a month and a half, they had laid a total of 1347, 720, 806, 856 and 850 eggs respectively. Breeding experiments in subsequent years with both the species, have confirmed these results.

## Agricultural Entomology

### 31. The cotton jassid, *Empoasca devastans* distant.

M. AFZAL HUSAIN *and* K. B. LAL, Lyallpur.

*Empoasca devastans* is one of the most serious pests of the American cottons in the Punjab. *Hibiscus esculentus, H. vitifolius, Solanum melongina, S. tuberosum* and *Althea rosea* are its alternative hosts and are often damaged severely.

The insect breeds practically throughout the year. Eggs are laid singly, usually in the leaf veins. Nymphs moult five times before becoming adults. One life-cycle—from egg to adult, may occupy from 11 days in autumn to 32 in winter ; the adults may live for over 3 months.

Damage is caused by the immature and adult stages, which suck juice from the leaves and inject some toxic substance which kills the leaf-tissue. The leaves develop brown spots, and crinkle.

*E. devastans* shows considerable varietal preference and there is some evidence to show that the resistance of a variety results from inability of the female to oviposit freely on it. The rôle of some factors supposed to confer immunity from jassid attack on certain varieties, was tested. Contrary to the common belief, hairiness of leaves while being associated with resistance cannot be held by itself to be responsible for jassid resistance.

As economic and effective control is only possible through the evolution of jassid resistant varieties and a thorough study of the characters which make a cotton plant immune or resistant is needed.

### 32. Studies and observations on the incidence and control of *Spodoptera mauritia* (Bosid) a major pest of rice in Cochin.

C. S. VENKETASUBRAN, Trichur.

Observations on the life-history, incidence, and control of *Spodoptera mauritia*, are presented. The distribution, occurrence, and habits of the pest, in the three main seasonal crops of paddy Virippu, Mundakan and Panja including Kole—are discussed in detail. The chief environmental and climatic factors that determine an incidence, are discussed. Control measures as practiced by the local agriculturists, and those evolved by the Entomological section, are described. Dusting with calcium arsenate diluted with lime in the proportion of one to six by volume has given very promising results. The main advantage of this dusting is that it can be carried out with success in dry as well as water fields alike. The operation is best carried out, as soon as, the larvæ hatch out from the eggs.

### 33. Observations on the sugarcane borer incidence at the Government Sugarcane Farm, Jorhat.

K. C. SHARMA, Jorhat.

The total borer incidence usually follows top shoot borer incidence. But there are exceptions in experiments in which lime and artificial fertilizers were used. In both cases top shoot borer was less prevalent.

There is a certain amount of difference in borer attack in the different varieties of canes.

There is a seasonal difference in borer attack.

In regularly attended plantations such as in an experimental farm, it may be seen that plant cane suffers more than ratoon cane from borer attack.

The cultural methods, i.e. the time of planting and also the spacing have some correlation with borer incidence.

Top shoot borer moths even in their gravid stage are more attracted by light traps than the stem borer moths.

## 34. *Semiothisa* (*Macaria*) *pervolgata*, a Geometrid pest of *Daincha* (*Sesbania aculeata*).

M. C. CHERIAN *and* B. RANGIAH PILLAE, Coimbatore.

A Geometrid moth—*Semiothia* (*Macaria*) pervolgata—does considerable damage to Daincha, an important green manure crop in the Madras Presidency. In 1936, a two-acre plot under this crop was completely defoliated by these caterpillars. The life-cycle of the pest occupies 17–24 days, the egg, the larval and the pupal periods being 3–4, 8–12 and 6–8 days respectively. A Braconid parasite—Apanteles sp., was noticed in numbers on the caterpillars. The remedial measures tried, include light traps, insecticidal trials, handnetting, etc.

## 35. Studies on *Laphygma exigua*, Hb., and its natural enemies.

M. C. CHERIAN *and* M. S. KYLASAM, Coimbatore.

As far as the authors are aware, *Laphygma exigua*, Hb., though known to have a wide range of host plants in North and South India, has not been recorded as a pest of tobacco nurseries. The environmental conditions under which the caterpillars assume the pest form are indicated and a brief account of the nature of cultivation prevalent at Chirala and outlying parts is given.

The habits and the general bionomics of the moth and the caterpillars are given in details ; the nature and extent of damage to tobacco nurseries is indicated. A sand dune weed *Gisekia pharnaceoides*, St., has been found as an alternate host on which the pest bred both during on and off-season.

Light trapping, trap cropping with *Eleusine coracana*, spraying with lead arsenate powder and hand picking of caterpillars are some of the measures adopted by the growers.

A few experiments in control performed at Coimbatore are briefly indicated. Attempts at the utilization of the predatory Reduvid bug *Rhinocoris fuscipes*, F., and the Tachinid fly *Sturmia inconspicuoides* have shown that the former alone holds out promise.

## 36. Effect of bollworm attack on the number of seed, lint weight, seed weight and ginning percentage of clean locks in partially damaged bolls.

H. D. NANGPAL, Hyderabad (Deccan).

The bulk of 'clean' cotton picked from a field is generally a mixture of cotton from bolls having all locks sound and from bolls having only two or one lock sound. The cotton from bolls, with one or two locks damaged does not have the same weight as those from bolls having all locks sound. This difference is more pronounced when the bolls are attacked in their earlier stages of development. Even sound locks in such bolls are small, with fewer seeds and poor lint. The differences in the number of seed per lock, seed weight and lint weight per seed and per lock and ginning percentage of clean locks derived from bolls having one or two locks damaged and of clean locks from sound bolls have been studied. In addition to this the locks from bulk clean cotton and total saleable

cotton have been compared with clean locks from sound bolls. It has been determined that the locks from sound bolls have more seed per lock, have more seed weight and lint weight, and give a higher ginning percentage than the locks from damaged bolls. The loss in the crop due to bollworm attack when calculated on the basis of clean locks derived from sound bolls is always higher than the one calculated on the basis of total clean locks (bulk) from a plot.

## 37. Incidence of spotted bollworm attack on cotton at Parbhani (Hyderabad-Dn).

H. D. Nangpal, N. T. Nadkarni, *and* T. E. Krishnaswami, Hyderabad (Deccan).

Two different species of the spotted bollworms—*Erias fabia* Stol and *Erias insulana* Bosid—damage the cotton crop in Hyderabad-Dn. The former is more common and is met with throughout the period the cotton plants stand in the field, while the latter is present in some numbers in the beginning and towards the end of the season. Their incidence on the crop is greatest during which period most of the damage to the green forms is done. In a bad year as many as twenty-five per cent., of the buds and about forty per cent., of the bolls are found to be attacked by spotted bollworms. Most of the attacked forms get shed and bollworms are responsible for more than fifty per cent. of the shed forms. After about the first week of December their activity declines and the percentage of incidence is lessened. Once again towards the end of February a slight gradual increase in the percentage of forms damaged by spotted bollworms is noticed.

## 38. A caterpillar pest of champaka (Michelia) in South Malabar district.

T. V. Ramakrishna Ayyar, Madras.

The champaka (*Michelia Champaka*), apart from its value as a timber tree, is ever green, and its sweet smelling and beautiful golden flowers command a good market in all villages and towns. It thrives along the foot-hills and uplands of the Western Ghats and is commonly cultivated round about temples, being one of the trees held in some veneration by Hindus, in many localities. The writer has on his farm, in the South Malabar district, a few young champaka trees and recently these were attacked by the leaf-eating caterpillar of *P. agamemnon* (Papilionidae). The bionomics of this insect is presented.

## 39. A new *Cecidomyiad* pest of Moringa.

M. C. Cherian *and* Mohamed Basheer, Coimbatore.

A study of the fauna of the flower buds of *Moringa pterygosperma* has revealed the presence of different insects such as Cecidomyiads, Pyralids, Thrips, Braconids and Chalcids. Of these, the first one, noted as a pest of moringa buds was described as a new species by M. S. Mani of the Indian Museum, Calcutta. A short account of the bionomics and natural enemies of this insect is presented. Control measures tried against the pest are also briefly indicated.

## 40. The amaranthus stem weevil of S. India (*Lixus brachyrrhinus* Boh.) and its parasites.

P. N. Krishna Ayyar, Coimbatore.

In an attempt to evolve a system of biological control of the cotton stem weevil (*Pempheres affinis* Fst.) one of the difficulties experienced

was the scarcity of the host during the greater part of the year for the artificial multiplication of the parasite. A subsidiary host was found in the common amaranthus stem weevil (*Lixus brachyrrhinus* Boh.). It is easily available and regularly abundant and has yielded satisfactory results for maintaining a stock of a few of the more important parasites of Pempheres, although not for their rapid multiplication. This useful laboratory host is of a further interest as it harbours a relatively rich series of parasites, some of which may be expected to transfer their attention to the cotton stem weevil.

The bionomics of *Lixus brachyrrhinus* has been studied.

About eleven species of Hymenopterous parasites—seven chalcidoids and four braconids—have been bred out of the immature stages of the weevil. Among these *Tetrastichus dinarmus* and *Spathius* constitute the more important ones. All the parasites are ectophagous with the exception of *Tetrastichus* sp. which is an internal feeder. An undetermined chalcidoid is an egg parasite.

Observations of the life-histories of many of these have been made.

## 41. Measures against sugarcane pests in the Jullundur circle.

M. Fateh-ud-Din *and* Bh. Dalbir Singh, Jullundur.

There is rapid increase in the cultivation of improved cane and in one locality the area under Coimbatore types has risen from 15,670 acres in 1929-30 to 95,831 acres in 1936-37. But the top-borer and pyrilla are the serious limiting factors in the spread of high yielding canes. During 1934-35, the top-borer attacked, on an avarage 60 per cent. of the shoots; and pyrilla damaged the crop so badly that cane tops were even refused by cattle and gur of very poor quality could be obtained. Because of low recovery of sugar from the pest affected cane, the Jagatjit Sugar Mills, Phagwara, had reduced the price of cane to 2·5 annas per maund, and the growers preferred to sell their cane even at this low rate.

Regular campaigns against sugarcane top-borer and pyrilla by simple methods have been conducted in compact blocks of several villages. Two years' results are available.

Hand-picking of moths and egg-clusters of the top-borer and the removal of borer-affected shoots, reduced the top-borer attack in the treated areas from 3 to 5 per cent. as against 30 to 40 per cent. in the untreated localities.

Hand-netting of pyrilla adults early in the season and crushing the egg-clusters simultaneously gave very satisfactory results.

The total cost of all these control operations, by engaging hired labour was Rs.3-12 per acre. In the case of ordinary peasants, who attended to these simple operations themselves the cost was nothing and crop remained healthy.

# Horticultural Entomology

## 42. An annotated conspectus of the insects affecting fruit crops in South India.

T. V. Ramakrishna Ayyar, Madras.

Among the problems which face a fruit grower the insect problem is perhaps the most important. Information on the entomological aspect of fruit growing in S. India, is presented.

## 43. Some observations on the bionomics and control of fruit fly pests in the N.-W. Frontier Province.

H. S. PRUTHI *and* H. L. BHATIA, New Delhi.

The fruit flies are of importance in almost all fruit growing tracts of India. Pears, peaches, loqats, guavas, apples, mangoes, etc. all suffer from the ravages of these flies. Observations have been made on the biology and life-history of these pests in the North-West Frontier Province, where pears and peaches suffer most badly. A number of sprays, baits, and repellant has been tried, the result of which are briefly summarized.

## 44. On *Agrilus citri* Thery (Buprestidae), a pest of *Citrus acida* in Bihar.

B. B. BOSE, New Delhi.

The buprestid grubs which are popularly known as flat-headed borers feed on the sapwood just beneath the bark of the host trees, sometimes killing them outright.

The genus *Agrilus* is very large and contains nearly 1,100 species, of which 38 occur in India.

*Agrilus citri* Thery is being recorded from India for the first time. It was obtained from a tree of *Citrus acida* at Pusa which was killed by the ravages of its grubs. A seedling of this which had been planted in the compound of the Insectary at Pusa in 1926 and which up to 1933 gave good size fruits in large numbers was found in June 1934 to be suddenly dying away and its leaves had turned yellow. On examination grubs, pupae and beetles of *Agrilus citri* were found in its trunk and branches. The nature of damage by the grubs has been described.

This pest was found to be parasitized in the grub stage by the braconid parasite.

The various stages in the life-history of the pest and its parasite *Spathius* sp. have been described and illustrated. The parasite has not yet been identified specifically and is new to the collection of the British Museum (Natural History), London.

## 45. Studies on the coconut beetle (*Oryctes rhinoceros,* Linn.) in South India.

M. C. CHERIAN *and* K. P. ANANTANARAYANAN, Coimbatore.

The palm beetle (Oryctes rhinoceros, Linn.) has long been recognized as one of the major pests of the coconut palms in South India. As supplementing work already carried out in the past on the subject, the present paper deals mainly with the observations made at Coimbatore, during the past two years, with regard to (1) life-history, (2) habits of the larval and adult stages, (3) nature and extent of damage, (4) seasonal incidence and breeding activity in the field, and (5) the control methods tried. The paper includes also some interesting observations on the activity and breeding of the beetle in captivity.

## 46. Preliminary studies on the biology of the mite (*Tetranychus* sp.).

A. N. SAPRA, Lyallpur.

This species is a serious pest of cucurbits especially 'tindas' (*Citrullus vulgaris* var. *fistulosis*). It has been collected from sixty different plants at Lyallpur, but tomatoes, pulses, beans and cabbages are more seriously infested.

There are five stages in the life cycle of a female and only four in that of a male, one of the nymphal stages being absent. Parthenogenesis is common and the parthenogenetically laid eggs produce males only.

This mite becomes active in March and by the end of April it is present on most of its food plants. This activity is maintained till July, when monsoon rains kill all stages except the eggs which carry on the infection. During September and October all stages of the pest are present. By the middle of December only gravid females remain which over winter.

A male dies within 48 hours after copulation but lives for 5–8 days if unmated. The female lives for 8–12 days during which period it lays 32–93 eggs at the rate of 4–15 per day. The incubation period and the duration of immature stages during April–September, is 3–5 and 2–4 days; and reach the maximum of 30 and 27–33 days respectively in December to January.

## Parasites of Insects

### 47. Mass breeding of *Microbracon greeni*, Ashm.—an ecto-parasite of the larva of *Eublemma amabilis* Moore, predaceous on lac.

S. N. Gupta, Namkum.

Successful biological control of an insect necessitates easy and efficient breeding of the parasite, determination of correct concentration of host and parasite, period of their contact, stages of liberations and efficient methods of transport and liberation.

The paper describes the evolution of a most convenient and effective oviposition case consisting of a round 12″ × 4½″ culture jar and breeding devices leading to breeding in lac domes. The most suitable contact period of parasite and host was 3–4 days in summer, 3–5 days in autumn and 4–6 days in winter. The best concentration of parasite and host, in the cage of above size, was 10 male and 20 female parasites to 40 host larvæ. Breeding eggs or larvæ of about the same age reduces cannibalism, etc. and increases the effective rate of breeding. Use of lac domes and spinning disc in breeding was found superior to breeding in glass blocks.

The most convenient stage to transport the braconid parasite, either for liberation in fields or to out stations for breeding is the cocoon stage. This is best done either by allowing the parasite to pupate in specially evolved spinning discs described in the paper, or in lac domes. These are to be kept in pockets of 20 mesh iron wove wire net.

The method has proved effective in breeding *Microbracon hebetor, Aphrastobracon flavipennis, Elasmus claripennis* and *Cedria paradoxa*. The points essential to success of mass breeding are: adequate supply of air, space, reflected light of moderate intensity and fresh food in oviposition cages. Excessive draught, humidity and hiding places in the oviposition cage should be avoided. Cleanliness of the cage and vessels used, prompt removal of dead parasites and protection against ants are necessary.

### 48. A preliminary note on the bionomics and mass-breeding of *Trichogramma* sp.

A. G. Hussain, Lahore.

Two species of *Trichogramma* parasitize *Argyria sticticraspis* and *Chilo zonellus*. These parasites have been bred on eggs of different insects. The duration of life-cycle varies with the hosts, from five to seven days. Further the duration of the life-cycle and longevity of the adult life varies with temperature. The optimum range of temperature

and humidity is 25°C. to 30°C. and 70 per cent. to 100 per cent. respectively.

No polyembryony has been noticed, but more than one egg may be laid in the same host egg.

The size of the individual varies with the number of parasites developing in the same host egg. The developing larvæ of the parasites get food by producing a current of food particles within the host egg.

For mass breeding, it is necessary to get a suitable host which can breed throughout the year and can lay a large number of eggs. *Sitotroga cereallela* has been successfully bred and a special apparatus has been designed to collect moths and their eggs in large numbers.

## 49. A trachogrammid chalcid parasite of the egg of *Eublemma amabilis*, Moore, predaceous on lac.

J. N. SINGH, P. S. NEGI, M. P. MISRA, *and* S. N. GUPTA, Namkum.

It is the first time that an egg parasite of one of the enemies of the lac insect has been discovered. The parasite is of great economic importance, as it will control the lac predator *E. amabilis*—which is responsible for 33 per cent. damage to lac crop—before it has done any damage. Its value in biological control is further enhanced by the fact that it also reproduces asexually.

Tentatively it has been placed under the genus *Pentarthron* family *Trachogramminidae*.

The male and female chalcid, the female pupa have been described. Mating and oviposition have been studied. The egg and the larval period in July-August is 5 days and pupal period 4-5 days. The maximum longevity of female was 6 days and average 2·4 days. On experimental basis 8 females parasitized 4·9 per cent. of 349 eggs offered to them ; 88 per cent. of the eggs laid developed into adult. In the field under natural conditions out of 2,898 *E. amabilis* eggs, on 1,327 inches of Ber (*Z. Jujbua*) lac stick, 3·8 per cent. were definitely found parasitized by this chalcid.

With the development of proper breeding technique and host and parasite concentration the chalcid is evidently destined to revolutionize lac cultivation.

## 50. *Apanteles tachardiae* Cam. and endoparasite of the larva of *Holcocera pulverea*, Meyr., predaceous on lac.

M. P. MISRA, S. N. GUPTA, *and* J. N. SINGH, Namkum.

The paper describes the mating and oviposition habits of *A. tachardiae*. In the laboratory the female allows the male to mate if starved from 5–8 hours. The longevity and the life history stages of the parasite are described in brief. The minimum and maximum life history period of males and females was 11 and 42 and 12 and 44 days respectively. The life-history and the number of generations during the year are discussed. There appear to be fifteen generations when pre-oviposition period is added to the average monthly life-cylce periods, but if the pre-oviposition is excluded the generations increase by two more. The relative prevalence of the parasite in various crops has been found to be in about the same proportion as that of the host. Parasitization of the host is more in *Katki* and *Aghani* than in *Baisakhi* and *Jethwi* crops.

## 51. *Pareuderus torymoides* Ferr, an egg parasite of the Amaranthus borer *Lixus truncatulus*.

TASKHIR AHMAD, New Delhi.

The life-history and habits of *Lixus truncatulus* a pest of cultivated and wild Amaranthus were reported by the writer last year (*Proc. 24th*

*Ind. Sci. Congress*, 1937). The eggs of this weevil which are laid inside the tissue of the host plant were found parasitized by a chalcid parasite, *Pareuderus torymoides* Ferr. This parasite is recorded from India for the first time.

The parasite lays a single egg on the host egg. On hatching the young parasite grub punctures the host egg and feeds on it. Its larval life is completed on a single egg and when full grown it pupates in the same cavity.

At 27°C. the egg stage lasts about one day, the larval stage 5-6 days, and the pupal stage about 5 days. Thus one generation of the parasite is completed in about 12 days as against roughly 2 months required by the host. It develops comparatively much more quickly and thus exercises considerable check on the multiplication of the weevil. The anatomy of different stages in the life-history of the parasite is described and illustrated.

## 52. A chalcid parasite of the linseed midge, *Dasyneura lini.*

TASKHIR AHMAD, New Delhi.

*Dasyneura lini* Barnes has recently been reported as a new pest of linseed by Pruthi and Bhatia (*Proc. 24th Ind. Sci. Congress*, 1937). This pest is found on *Cajanus indicus* also, and is widely distributed in North India.

During the spring of 1937 while this pest was being studied at Karnal, Punjab, it was discovered that its larvæ were attacked by an important chalcid parasite which is yet awaiting identification. The bionomics of the parasite is described in the present paper.

The parasite lays its eggs singly inside the crumpled buds of linseed harbouring almost full grown host larvæ. The eggs hatch in 2-3 days at 13°C., and in 3-4 days in the field during February. The eggs are not laid on the body of the host, therefore, the young grub on hatching wanders about in the bud in search of the host. It is fairly hard and can stand starvation for about 24 hours. In order to complete its larval stage the grub requires 2-3 host larvæ and this number is usually always found in affected buds. At 18°C. the grub pupates after 12-15 days within the bud and the adult emerges after another 11–13 days. Thus under these conditions one brood is completed in a little less than a month. During February it was estimated that roughly 50% of the full grown host larvæ were being killed by the parasite grubs.

## 53. Notes on a braconid parasite of the wax moth (*Galleria mellonella*).

M. C. CHERIAN *and* S. RAMACHANDRAN, Coimbatore.

A braconid parasite was noted for the first time in South India on the wax moth—*Galleria mellonella*, a serious enemy of the honey bees. An attempt was made to study the life-history and habits of the parasite to see whether the results obtained would throw some light on the possibilities of biological control of the pest. Information on the parasites is given under the following heads :—description of the adult, life-history, parthenogenesis, longevity, seasonal incidence, other hosts and status of the pest.

## 54. *Rhaconotus scirpophaga*, a parasite of the sugarcane white moth borer (Scirpophaga).

M. C. CHERIAN *and* M. ISRAEL, Coimbatore.

As a result of the intensive study of the natural enemies of *Scirpophaga* in Coimbatore seven larval parasites have been collected. A paper on

*Stenobracon nicevillei* was submitted to the Indian Science Congress, 1936; another one on *Elasmus zenhtneri* has been sent to the Madras Agricultural Journal for publications; *Rhaconotus scirpophaga*, yet another parasite, is the subject matter of the present paper. Interesting information on the habits and life-history of the parasite, egg-laying capacity, longevity, etc. is given and the status of the parasite discussed.

### 55. The bacterial flora in the gut of the larvæ of the cocoa moth, *Ephestia elutella* Hb.

S. E. JACOBS *and* D. P. RAICHOUDHURY, Calcutta.

*Ephestia elutella* larvæ have been shown to harbour a streptococcus in their intestines. The organism occurred in large numbers only when food had been recently ingested. It rapidly died out when food was withheld, and was absent from hibernating larvæ. The organism was described and shown to produce acids from carbohydrates. It was very sensitive to these acids, and died out fairly rapidly in such cultures. The organism cannot hydrolyse starch, and must depend for its nourishment on a diastase secreted by the larvæ, whereby sugars useable by the streptococcus are produced. The presence of the organism in the food led to its appearance in the intestines. The organism was not essential to the proper development of the larvæ. The possibility of the organism having some adverse effect on the larvæ is briefly discussed.

## Insect Vectors

### 56. The cotton white-fly as a vector of the leaf curl disease of tobacco.

H. SINGH PRUTHI, New Delhi.

Tobacco suffers from leaf curl or crinkle in several parts of the world, e.g. East Africa, Rhodesia, India, Java, etc. In India the disease is most common in the Gangetic delta region, especially Bihar, where sometimes 60–70% of the plants are affected. As the value of tobacco crop is almost wholly dependent on the nature and texture of its leaves, the economic loss due to this disease can be easily imagined.

The disease belongs to the virus group. Most virus diseases are known to be transmitted by insects. Observations on the disease have been taken and a large series of transmission experiments performed at Pusa during the last three years. They are very briefly reviewed in the present paper. The work indicates that *Bemisia gossypiperda*, M and L—the common white-fly of cotton is the most important transmitter of disease, from diseased to healthy tobacco. Some alternate hosts of the disease have been discovered and in their case also the white-fly has been found to be capable of carrying the disease from diseased plants to healthy plants of the same species as well as to tobacco.

The technique followed in transmission experiments is described in detail.

## Statistical

### 57. The relative efficiency of some methods for comparing jassid population in cotton fields.

K. B. LAL, New Delhi.

*Empoasca devastans* Distant, which mainly infests the American cottons in the Punjab, shows considerable varietal preference. To measure

the incidence of this pest in different plots it is necessary to determine the density of population. Four methods have been tried.

1. Collecting adults by sweeping with a net and counting them.
2. Killing nymphs and adults on a plant by fumigating and determining the population.
3. Removing leaves from a plant and calculating the number of nymphs per unit area of loaf surface.
4. Counting adults and nymphs in the field by examining individual plants.

The data obtained have been examined by the method of analyses of variance. The first method is sufficient for comparing the numbers of adults jassids in adjacent plots but fails if the plots are at some distance apart. The second method is satisfactory for adults but not for nymphs. A pretty accurate nymphal population is given by the third method and the fourth is more satisfactory (for nymphs only) if a certain degree of intelligence is assumed on the part of the observers.

In view of the fact that jassid attack is not uniform in cotton fields, the accuracy of population estimations of this insect would depend on a large number of small samples drawn from all parts of the field.

# SECTION OF ANTHROPOLOGY

*President:*—B. S. Guha, M.A., Ph.D., F.N.I.

## 1. A plea for a new outlook in Anthropology.

S. C. Roy, Ranchi.

In this paper the author pleads for greater attention than has been hitherto paid by Indian anthropologists to the psychological and spiritual (in the widest connotation of the term) side of human society and its growth, than to the physical side of man and the technical side of human culture. Not that the study of these latter aspects is to be neglected, but the students' interest in them, should, the author thinks, be subordinate and ancillary to his interest in the former.

As the cultural and spiritual side of man constitutes the real essence of humanity and distinguishes Man from the rest of the animal creation, it is fitting and proper that in India at any rate, the science of Man should be classed apart from Zoology and not as part of it, as the National Institute of Sciences of India has thought fit to class it. The author has pleaded for this line of approach on some previous occasions, but he thinks it will bear repetition as it requires to be stressed.

## 2. In how far national or racial cultures are distinct from one another.

J. F. Bulsara, Bombay.

People speak and write vaguely about 'Western Civilization' and contrast it with the 'Oriental', and some speak equally ambiguously of 'Western Materialism' and 'Eastern Spiritualism'. Some also speak of the distinctive cultures and cultural complexes of various lands or peoples, e.g. of the Japanese Spirit, Chinese Civilization, German Kultur and Aryan Origins. To understand this alleged difference of cultures of two arbitrarily demarcated areas of the globe, or of various races or peoples, we have to enter into a deeper analysis of the factors that constitute culture and civilization and view them in relation to the peoples or races that have evolved them. Some of these factors are superficial and some essential, such as clothing, manners, etc. on the one hand, and social and political organizations, etc. on the other.

It may be found that in the superficials of culture there is an apparent wider divergence, while in social organization, status of sexes, individuals and classes also, there are differences, but in the more essential factors of social justice, spiritual values and aims and objectives of life, the difference between the so-called Oriental and Western civilizations is not so great. Besides, it is difficult to demarcate geographically, racially or even nationally the areas or peoples who are Eastern in their entire outlook and contents of culture, or are entirely Western.

One great factor that emerges from a deeper analysis is the gradual modernization (i.e. the acceptance of ideas that make for efficiency) of the peoples of the world, and also that the ultimate higher values of civilization are getting to be common to all peoples of the world, though some nations may be accepting and assimilating them quickly

while others may be doing so more gradually and haltingly. Whether all races of mankind can in a given period of time and under favourable conditions, assimilate the ultimate higher values of civilization equally with the so-called civilized ones, is a problem worthy of closer scientific investigation.

## 3. The crisis in modern Anthropology.

BARON VON EICKSTEDT, Breslau.

This lecture wants to show the development of the different trends in Anthropology in various ages and countries and their connection with the main mental situations and movements. Anthropology is taken here only in the meaning of biological research in anthropos himself, the only real science of man, races and humanity. A critical observation of the historical development of its notions and methods reveals at once certain logical contradictions and a number of vague applications. They are the real reasons for the present critical situation in Anthropology which has the possibility of enormous progress and therefore an enormous spreading of misunderstandings also. The way out of these difficulties is shown by modern holistic anthropology with its logical frame and scientific biological basis.

## 4. The significance of cowrie shells in Khasi ceremonies.

DAVID ROY, Shillong.

At the crossing of three roads a cowrie shell is thrown on the ground and the name of the person who died far away in foreign lands is called, and the shell is brought home on a piece of white cloth. This shell is placed with the bones and ashes of those who died at home; these remains of the dead are interred in the family tomb stone—the dolmen which is the 'Mawbah' of the family. The significance of this ceremony with the cowrie shell in Khasi life is simple and clear, and no one can dispute the sanctity of its purpose. The dead, the irrecoverable remains of the dead, are brought and made immortal in the cowrie shell and the full person of the dead is there in its entirety.

The use of shells by the Khasis in invoking the spirit of the departed and bringing back that spirit to life seems to signify that the shell is endowed with the power of the giver of life which it simulates.

Khasis have an intimate knowledge of the anatomy of the human body and the functions of the various organs. They know that life in its embryonic stage was formed in the uterus, and it is associated with the opening of the portal of life, by which we all enter the world. Perry says that the cowrie shell, as the symbol of fertility and birth, has always been closely associated with women. It was the symbol of maternity. Khasis say, from woman springs the kind 'Da ka kynthei long jaid', and speak of man as the giver of the seed, 'U Kpa uba ai ia ka rynieng [lit. the father who gives the stature (person) ].

In the plants and the seed that they put down to grow they notice that plant life cannot thrive without water and so, as Khasis got from the food collection to the food productions stage, they must have realized the part played by water in the production of life. Thus the cowrie is thrown on the ground and rice is scattered on it and water is sprinkled and the name of the deceased is called. The person of the dead in the halo of its sacredness is represented in the bones and ashes of the dead, and these remains are brought with ceremonial performances to the family dolmen, Mawshieng. In case these remains could not be obtained, the cowrie shell, the rice and the water are used to call back the person, Rngiw; and this Rngiw in the shell represents the thing in which his person can permeate. Thus Khasis call back the *Rngiw*, and that spirit from the regions unseen by the naked eye to a static life of continued existence

in a world of fuller realization of the home of true kinship. Man in his *Rngiw* is immortal; this Rngiw is born of God and it is supported in life by feeding the physical in man, and is revived again by the water of life. The dead, the irrecoverable remains of the dead one, are brought and made immortal in the cowrie shell; and the full person of the dead, the Rngiw and its spirit are there in their entireties.

## 5. Considerations concerning the Ethnology and Early History of the countries bordering on Tibet.

F. W. THOMAS, Oxford.

## 6. The coining technique of the Yaudheyas.

B. SAHNI, Lucknow.

While several coins of the Yaudheya republics have been known to numismatists for some considerable time, our knowledge of the technique employed in their making is extremely meagre; and so far as I am aware, no records exist of the mints from where they were issued.

In 1936 (Current Science, 4: 796–801) the author briefly announced the discovery, among other relics, of the site of an ancient mint of the Yaudheyas (*ca.* 100 B.C.) in the Khokra Kot mound at Rohtak, about 40 miles west of Delhi. Two visits were paid to the site in 1936, and several thousands of coin moulds were recovered from a level about 3 feet below the surface. In March, 1937, I showed the site to Mr. K. N. Dikshit, Director General of Archæology, and a few more fragments of moulds were collected.

The main object of the present communication is to describe in some detail the coining technique which was briefly indicated in the preliminary note. Incidentally the archæological importance of the Khokra Kot mound is stressed. As suggested in 1936, a systematic excavation of the earlier strata holds out a promise that here we may be able to narrow down, if not completely bridge, the great gap in our knowledge between the 'prehistoric' period of the Indus civilization, and the historic period, which at present is known to extend back only to a few hundred years B.C. It is gratifying to know that the Director General has agreed to have the mound excavated. Possibly it will prove to be one of the few sites in India which have been in occupation, off and on, since the Harappa times; the modern city of Rohtak stands on the southern portion of the mound.

## 7. The Nal pottery.

N. G. MAJUMDAR, Calcutta.

In 1903, a number of polychrome vases bearing geometric patterns were discovered by Mirza Sher Muhammad in the Sohr Damb mound at Nal in the Kalat State of Baluchistan and subsequently sent to the McMahon Museum at Quetta. An account of it was published by Sir John Marshall in the Annual Report of the Archæological Survey of India for 1904-05. In 1925, Mr. Hargreaves of the Archæological Survey was deputed to Nal for a systematic exploration of the site. This resulted in the discovery of prehistoric burials, and from them were recovered further examples of the same polychrome pottery. Since then, it has received further attention from scholars in connection with the discoveries at Mohenjodaro and other sites of the Indus Valley.

During the author's explorations in Western Sind in 1929-30 and 1930-31, polychrome vases with geometric patterns, which recall to some extent the Nal examples, were excavated at a number of sites. This has now necessitated a fresh study of the Nal pottery. A major part of the Quetta collection of this pottery has now been transferred to the Indian Museum, Calcutta, after the destruction of the McMahon Museum

in the recent earthquake. In the present article, an attempt has been made to indicate tentatively the position in order of sequence of this pottery, and also of the kindred wares from Sind and Baluchistan. It has also been suggested that to obtain a more definite idea of their sequence, further excavations and researches in this terrain are necessary.

## 8. Further discoveries of Palæolithic cultures in the North-West Punjab.

D. SEN, Calcutta.

In this paper the author first outlines the prehistoric geology of the north-west Punjab, and then gives a typological estimate of the palæolithic cultures found in course of his tour. He has particularly dealt with the lower palæolithic cultures, which are essentially composed of a coup-de-poing industry represented by a variety of forms from primitive to more evolved types. The author thinks that a core-tool-people may have been the early settlers in the plains of the Punjab, having emerged during the closing stages of the Siwalik history, and initiated the pebble or core culture with coup-de-poing as their type tool par excellence. The flake cultures are also typologically determined. They had a more or less parallel evolution within the core-tool-civilization of the lower palæolithic period, but developed and established as a distinct culture in the middle palæolithic period.

## 9. Height and Cephalic index of the Bengali students.

A. N. CHATTERJEE, Calcutta.

Introduction—Conclusions based on examination of 9,240 University students above 18 years of age in the following proportions: Brahmins—3,017, Vaidyas—716, Kayasthas—2,499, other Hindu castes—2,097, Mohammedans—919—Av., S.D., and percentage distribution of height and cephalic index in the different classes tabulated district by district (25 tables).

Class differences:—The differences among the different classes in the same district are extremely small—Brahmins show a tendency to tallness,—the Mohammedans a tendency to shortness—distribution of cephalic index variable—peculiarities of distribution pointed out.

Effect of urbanization—extent of Brachycephaly among the Brahmins and the Kayasthas.

Variations in districts studied from 10 district maps of Bengal showing distributions of criteria—trends and tendencies—correlation of height and cephalic index.

The following areas distinguished:—

(*a*) of Brachycephaly with tallness in South-Central Bengal,
(*b*) of decreasing Brachycephaly with tallness in West-Central Bengal.
(*c*) of increasing Dolichocephaly with shortness in—(i) South-West Bengal, (ii) North Bengal, (iii) South-East Bengal.

Conclusions.

## 10. Anthropological research in Southern India.

LIDIO CIPRIANI, Florence.

In 1934-35, the author carried out anthropological and ethnological investigations in Southern India and Ceylon, particularly in Coorg, Cochin and Travancore. He took anthropometric measurements on 2,323 individuals belonging to 36 castes or groups and collected many samples of hair, numerous ethnographic objects, etc. He has analyzed the somatic features

of the Coorgs, Yeruvas and Kurumbas, male and female and has compared them with the Kadirs, Kanikkars and Uralis.

## 11. The Radhiya and the Varendra Brahmans of Bengal.

T. C. Ray Choudhury, Calcutta.

The author discusses the relationship of the two—based on the somatometric measurements and physical observations and thinks that both may be considered as members of the same racial group. Both of them are again compared with the Kanaujiya Brahmans and are found to be distinguished from them in important physical characters.

## 12. The functions of Physical Anthropology.

R. A. Fisher, London.

(In collaboration with the Statistical Conference.)

## 13. Indian oil presses.

K. P. Chattopadhaya, Calcutta.

In an earlier paper, the writer pointed out that primitive oil press is found in Nepal, in association with an early culture in that area. The early culture was characterized by certain special features, which revealed that it reached Nepal from India, prior to the incoming of Vedic Indo-Aryans.

The oil press consists of two planks, generally a log sawn in two, fixed to an upright post at one end. The oil seed is introduced between the logs and then pressure is applied by means of a lever. The oil press is found in Nepal and Assam among non-primitive social groups ; and in Chota Nagpur, Central Provinces and Madras among primitive tribes. A cruder form of the press is found in Assam and also in the Nicobar Islands.

The different types of oil-mills in India are then described. The South Indian mill has a stone mortar. In Bengal and Gujrat, the oil-mill has a wooden mortar. But it is often without a hole. Elsewhere, in North India, the mortar has a hole to drain the oil. The terms applied to the mill and certain subcastes in different areas also show some peculiarities. With the exception of the *Tili* in Bengal, the oilmen are generally regarded as impure, except in Nepal and Assam.

The possible origin of oil making by boiling, among a hunting and fishing people is discussed. The possible development of the oil press—by way of the tree-press of Assam and Nicobar—is then indicated. The invention of the oil-mill, following the line of development of a rotary quern from handmills, is next considered.

The writer concludes that the earlier form of the oil-mill in India is the South Indian type with its stone mortar. It has spread from this area to North India.

## 14. Polyandry in Kota society.

David G. Mandelbaum, Ootacamund.

While a woman may have but one legal spouse, the brothers of the husband have sexual access to her and act as secondary husbands. This fraternal polyandry is founded on a functional principle which pervades other aspects of the culture, the principle of the equivalence of brothers. A set of brothers share equally in economic and personal life as well as in the marital sphere. Classificatory brothers and real brothers have uniform rights where non-material phenomena are concerned, but in regard to tangibles, uterine brothers take precedence. When the fraternal principle comes into conflict with another of the major themes of the

culture, it is sometimes cancelled, sometimes dominant, depending on its effective rating in the particular situation. Intrafraternal jealousy is sternly quelled, but the numerous and violent quarrels between brothers about property may be the reverberations of repressed sexual hostility. Despite the inroads of foreign traits, the fraternal principle is still economically valid. Hence polyandry still flourishes.

## 15. Clan-monopoly of personal names among the Purum Kukis.

T. C. DAS, Calcutta.

Among the Purums—an Old Kuki tribe of Manipur in Assam—each clan exercises monopoly right over a number of personal names. The members of the clan are required to select names from amongst this group. Infringement of this rule is punished with a pig and a pot of *Zu* (rice-beer). In the earlior days each clan had a number of fixed names handed down from generation to generation, but at present the number has increased and new names have been added. The clans too have extended monopolistic right over these new names.

## 16. Kinship and marriage among the Coorgs.

M. B. EMENEAU, Ootacamund.

The Coorgs are organized in exogamous patrilineal sibs. A woman on marriage takes her husband's sib-name, and by a contract which forms part of the wedding ceremony gains right in his sib and loses effective membership in her father's sib. She may regain membership in her father's sib if divorced, and this may happen only if the consent of her father's sib is obtained. A ceremony corresponding to that at marriage must take place in which she renounces membership in her husband's sib. A similar ceremony takes place if, when widowed, she marries a man who does not belong to her first husband's sib. Details of the marriage ceremonies are described. One detail shows clearly that cross-cousin marriage, which is common at present, is regarded as preferable. Cross-cousin marriage is of the symmetrical variety. The kinship terms used by the Coorgs are given and discussed.

## 17. On the Anthropology of the Todas.

LIDIO CIPRIANI, Florence.

119 Todas, 61 males and 58 females, were measured by the author at Ootacamund (Nilgiris) in 1935. In his analysis he has considered several combinations of characters together. The two sexes show differences in characters both qualitative and quantitative, and the author concludes that in the small series, there is a certain Australoid affinity as indicated by tall stature with arms rather short or medium and a short bust; and the women show some negroid features as shown by rather high stature, long arms and short bust. The women also show a larger percentage of dark eyes. The Todas are not therefore a pure type, segregated and unchanged but they have been immune from any recent admixture such as that from the Dinaric type of Coorg.

## 18. Racial analysis.

H. J. FLEURE, Manchester.

In analyzing physical characteristics of men we have to remember that almost every population includes contributions from several in-drifts that do not completely blend.

Homo sapiens, with contributions to his characteristics from diverse hominids in various areas, developed his main characteristics in the area of distribution of Chelleo-Acheulian, Aurignacian and Capsian cultures under temperate conditions, probably in N. Africa and S.W. Asia, including early extensions to India. Principal drifts probably include :—

(*a*) a drift S. and S.E. from the zone above-named, characterized by a short head of breadth 140–145 mm., and cephalic index therefore 80 ±, nose broad and short, mouth prominent, hair kinky, eyes prominent, stature short, frequent steatopygy in women ;

(*b*) a drift chiefly S. and S.E. but also N.W. and eventually N.E. with very long head of breadth 140 ± mm., and thus very low cephalic index (usually 73·5 or less), strong brow ridges and cheek bones in most cases, hair fundamentally wavy, but, when these characters spread into regions with kinky hair, they may take on this character probably by intermixture. Stature moderate. Skeletal characters to some extent like those of Aurignacian men ;

(*c*) a large drift in all directions with moderately long head of slightly greater breadth than the above, and cephalic index therefore usually 73·5 78·5. Hair as for (*b*). Stature moderate to short. Major drifts south of the great mountain zone of northern hemisphere, but later spreads northwards as ice sheets diminished, that to the N.W. (in Europe) becoming depigmented ;

(*d*) a drift especially N., but to some extent also S.E. with cephalic index 80+ because the head is relatively short and has a breadth 150+. Rounded head contours, broad short face in most cases, rather short nose of moderate breadth, stature rather short. Specializations within (*d*) gives (*d*, 1) the men with high short heads and prominent noses, and cephalic index most often over 85, and (*d*, 2) the men with flat-topped broad heads and cephalic index 85 ± and often sunken noses. Arguments can be given for origins of these characters on N. side of the supposed original H. sapiens-zone above-mentioned ;

(*e*) What is possibly a special modification of (*b*) above—a drift out from the steppe in the 'Bronze Age' as dry warmth developed. Very long narrow heads with cephalic indices usually below 73·5, but long narrow faces and prominent narrow noses giving a strong profile perhaps linked but with general growth in length.

It seems highly probable that Mendelian inheritance occurs widely, and this provides an explanation of the undoubted fact of the persistence of these types side by side in a population. It is useful to attempt to analyze samples in the light of the above list of drifts, but dangerous to plead for them as universal standards of reference because they are only inferences and need checking and adjustment. The only safe way is to study the bundling of physical characters in individuals and to see what are the more general bundlings in particular populations. Examples will be given and discussed.

## 19. Inter-caste differences in blood group distribution in Bengal.

E. W. E. Macfarlane, Calcutta.

Blood group data were taken at Budge Budge, District 24 Parganas, from over 500 Bengalis. The caste and birthplace of each person was recorded. It was found that the percentages of A and B increase from

the high to the lowest castes. The Caste-Hindus have over 40% of O. The Depressed Classes show 42·7% of B, which is the highest value for B yet discovered. All groups show the characteristic Indian condition of more B than A. The blood group proportions of the Bengali Mohammedans resemble those of all the local low caste Hindus taken together. This demonstrates that they are descended from local Bengali Hindu converts. There is less difference in blood group distribution between the highest and the lowest castes in Bengal than between high castes and untouchables in Cochin. The reduced Coefficients of Racial Likeness agree with the evidence of blood group data for the Bengali Brahmins, Kayasthas and Pods, also for Nairs and Illuvas of Cochin. The fact that the Pods and Illuvas show an association by the C.R.L. and no resemblance in blood group distributions may be significant in relation to racial migrations and the time of origin of the B mutation in India.

## 20. Studies on the heredity of palmar pattern.

P. C. BISWAS, Calcutta.

This study is based upon the investigation of ten families, consisting of two and three consecutive generations. The main line formulæ, patterns on the hypothenar, thenar and interdigital areas and the occurrence of axial triradii show indications that they transmit hereditarily. Not only that but within families there occur patterns on the hypothenar and thenar eminences which resemble each other not only in their principal characters but even in some of their details.

## 21. Tri-clan and marriage-classes in Assam.

J. K. BOSE, Calcutta.

The importance of tri-clan and marriage-classes has been stressed by anthropologists. But up till now very little field-work has been done on this line in India. In this paper an attempt is made to discuss the different varieties of marriage-classes found in Assam. The materials for the paper in most cases were collected by the author in the course of his field-work amongst the little-known primitive tribes on the Burma border of the Manipur State during the years 1931–1935. The tribes in which this system was recorded are Chirus, Chothes, Purums, Taraos, Kabuis, etc. There is a detailed discussion with diagrams on the working of this system amongst these tribes in the paper.

## 22. The Palaungs of the Shan hinterland.

M. R. SAHNI *and* (MRS.) SHYAMA SAHNI, Calcutta.

The authors describe the social customs, migration, methods of cultivation and the geographical distribution of the *Palaung* clans and sub-clans inhabiting the Shan plateau. The *Draang* sub-clan, members of which build communal houses after the style of the *Dyaks* of Borneo, are of particular interest. The probable origin of some of the customs is discussed. The paper is illustrated by numerous photographs taken by the authors.

## 23. Dancing as a method of inducing ecstasy and frenzy.

N. N. SENGUPTA, Lucknow.

Dancing appears as a phase of religious rites. It is also a frequent accompaniment of religious festivals as an æsthetic phenomenon. The present paper is not concerned with either of these topics. Dancing is sometimes employed as a method of inducing a condition of religious

ecstasy. We find it in different parts of the world and in different epochs of history. It is found in what was German Africa, and in Sumatra as a mediumistic phenomenon. It appears in the context of *Shamanism.* It was an important ingredient of the cult of Dionysos in ancient Greece. It manifested itself as a craze in Aix-la-chappelle towards the end of the 14th century. We find it recommended as an efficacious religious procedure in the context of the Chaitanya school of Vaishnavism.

The paper presents an analysis of this phenomenon and proposes a psycho-physical hypothesis for its interpretation.

## 24. Comparative anthropometry of the Pundits and Muhammadans of Kashmir.

H. C. Chakladar, Calcutta.

The writer measured in last May and June, 206 Pundits who are the Brahmins of Kashmir, and also 52 Muhammadans of the same State in which 22 measurements on the head and 30 measurements of the body proportions, and 40 observations were recorded. The Kashmiris were found to be of medium stature and highly dolichocephalic. Their hair is fine in texture. The nose has generally a convex or straight bridge and is often aquiline. Neither the malar bones nor the angles of the lower jaw are prominent. The eye-slit is always straight and of moderate breadth. The colour of the iris was observed to be deep brown and brown, only a negligible fraction having eyes with grey shades. The hair is black in 70 per cent. of cases, and the others showed light shades of red. The skin colour is generally tawny white. The vast majority of the Pundits are thin and slender. The Muhammadans show hardly any appreciable difference from the Pundits in any of the features.

The people of Kashmir appear to be of the Mediterranean race, showing less admixture with the brachycephals than even the people of Southern Italy.

## 25. Interparietal bone in man.

R. Krishna Rao *and* A. Ananthanarayana Ayer, Vizagapatam.

A big Interparietal bone, which is usually considered by anatomists as an exceptionally rare and uncommon find, was observed in one of the crania in the Department of Anatomy. This provided an occasion for making a detailed study of this bone with special reference to its incidence in crania of this part of the country. The study of 194 crania available here in the Department of Anatomy reveals that the percentage of occurrence of this anomaly is 15·46 and that the bone may be single, bipartite, tripartite or quadripartite, the parts however never exceeding the maximum number of four. A brief account of comparative anatomy and ossification has been included in the paper.

## 26. An enquiry into correlations between stature and arm-length, etc. between different social and occupational groups of the people of Bengal.

Bhupendranath Datta, Calcutta.

For this purpose, 190 subjects from 33 groups are chosen and thus divided: Caste-Hindus, depressed castes, Moslems, aboriginals. Again, these into manual and non-manual classes.

By calculation, it is found that correlation exists between stature and arm-length, the same is with hand-length save the manual-labouring

class. Regarding hand-breadth, positive correlation exists only in 'All-Castes' group, but negative in stature and hand index. Again, correlation is positive between arm-length and hand-length. As regards arm-length and hand-breadth, correlations exist in 'All-Castes', 'manual' and 'non-manual' classes. There is no correlation in any group regarding arm-length and hand index.

Then the somatic proportions and ratio expressed in percentage are enquired into.

In conclusion it is found that, the Caste-Hindus are not dissimilar with the depressed castes except possessing longer hand-breadth and middle finger-length. But they are taller than the Mohammedans and possess longer hand-length and middle finger-length.

Again, there is no difference between the depressed castes and the Mohammedans, and the non-manual class is taller than the manual class.

## 27. The racial affinities of the Santals.

S. S. Sarkar, Calcutta.

The author has taken anthropometric measurements of 144 Santals from the interior regions of the Rajmahal Hills and has compared the metric data with those of the Mālérs of the Rajmahal Hills and the Mundas of Chota Nagpur. After a detailed comparison of the above data the author has come to the conclusion that there appears to be a fundamental difference in the headform and other somatic characters between the Mundari and Dravidian speaking peoples of Chota Nagpur. The Santals appear to possess a strong Australoid strain, in addition to a mongoloid element, as judged by the presence of epicanthic folds in their eyes and other characteristics.

## 28. The racial affinity between the Brahuis and the Dravidians.

C. R. Roy, Karachi.

The racial history of the Brahuis is a puzzle to the Anthropologist· Suggestion of racial connection with the Dravidians as they speak Dravidian language. Objections on the ground of supposed differences of physical features. Confusion of the Dravidians and Pre-Dravidians. Physical features of the Dravidians. They are akin to the Mediterraneans.

Haddon puts the Brahuis under the Indo-Iraneus group. Analysis of the anthropometric measurements of 100 Brahuis taken by the author shows a large percentage of the Mediterranean element. The original Brahuis belonged to the Mediterranean stock. They have been modified by the admixture of the *Homo Alpinus* and the Indo-Afgan. But they kept the original Mediterranean type among the higher classes. Social and marriage customs support the above analysis.

Common physical features point to the common origin of the Mediterranean, Brahuis and Dravidians. Dravidians entered India through the N.W. Frontier. Their possible route of migration. Type II Mohenjodaro skulls as described by Dr. Guha confirms the theory of the Mediterranean migration about 2000 B.C. Relics of common material culture. A characteristic type of basket found among the both. Language, physical features and material culture all point to the racial connection between the Brahuis and the Dravidians.

## 29. The relationship of the Austric-speaking tribes of India with special reference to the Hos and Saoras.

D. N. Majumdar, Lucknow.

## 30. Water-divining.

S. T. Moses, Baroda.

Water-divining and Animals. *Bhima's* horse. Water-divining and Man. 'Dowsing' an instinctive gift. Its uses and application in India. Krusadai island wells and salinity. Devaramalai well and 'Blood'. Dowsing and Rural reconstruction schemes. The Sceptic Linnaeus and his conversion. Explanation of the 'Dowsing' power. Scientific water-divining for borewells by the Industries department. Dowsing apparatus from Moses' Rod to Mansfield Patent Automatic Water-finder. Water-divining with cocoanut in Kerala. Well-digging in India. *Bhima* a water-diviner like Moses.

## 31. Studies in eyebrows among the Bengalis.

R. N. Basu, Calcutta.

Different forms of eyebrows—position of eyebrows—directions of the hairs—abnormal types of eyebrows—colour of the eyebrows.

## 32. Rudra-Çiva as an agricultural deity.

Nanimadhab Chaudhuri, Calcutta.

*Çiva* appears as a cultivator-god and a half-mad mendicant god of the lower classes in medieval Bengali literature. In Brahmanical society at the present time *Çiva* is specially worshipped as a giver of desirable husband and offspring, and as a curer of diseases. In non-Brahmanical society *Çiva* is worshipped as Mahadeva and under other names for the protection of cattle, recovery from illness, as a guardian deity of village and gate-keeper, and animal and other sacrifices are offered to him for good crops. In the Rig Veda, *Rudra* has no agricultural aspect. In the later Vedas, Brahmaṇas and Sūtras *Rudra* appears as a vagabond god of outcastes and skin-clothed forest and hill tribes, an inauspicious, malevolent god, a protector of cattle and a god connected with vegetation. In the Epic Age *Rudra-Çiva's* old attributes continue and new attributes are added. The old connection with vegetation develops into connection with food and agriculture, the means of producing food. The old vagabond god of outcastes is transformed by the addition of such attributes as 'Crazy', 'mendicant', 'clothed in rags', 'fond of dancing, singing and laughing', etc. The dual aspects of the medieval Bengal *Çiva* have thus been derived from earlier traditions.

## 33. Religious life of the Bunas of Bengal.

M. N. Basu, Calcutta.

In this paper the author discusses how the idea of religion came into the mind of the Bunas. The author also discusses the various worships of the Bunas and their origins and significances.

## 34. A preliminary study on the Brisakāstha of Bengal.

B. K. Chaudhuri, Calcutta.

*Brisakāstha* is the vedic *yūpa* transformed. Origin of the vedic *yūpa*. Evidences proving the existence of animal sacrifice (specially bull and cow) to the departed ancestors in the vedic and post-vedic periods. Provisional classification and description of the *Brisakāstha* of modern Bengal. Possible interpretations of the figure or figures carved on it. Method of disposal of the post and the underlying psychological concept discussed. Magical ideas associated with it pointed out. Distribution of the *Brisakāstha*. Its use as a memorial post, and as a post of worshipping

the departed ancestors. Traces of the conception of fertility cult as found along with it. Conclusion.

## 35. A comparative study of the Athgarh (Orissa) skull.

H. K. Bose, Calcutta.

The skull was recovered at the time of re-excavation of an old well from a depth of 7½ ft. in a soil consisting of clay and water. The skull along with other bones of the skeleton and two iron objects (*kātāri*) and one copper bangle was found underneath a layer of stone slabs measuring 2 ft. × 1 ft. presumably the contents of a megalithic monument.

A detailed study of its anatomical peculiarities is given and comparison made with skulls found in other megalithic sites.

## 36. Blood sugar of the normal Bengali—its interrelationship with some body measurements.

M. L. Chakravarty, Calcutta.

From analogy of some well-known diseases such as high blood pressure occurring in short-necked people, etc., the author attempts here to find out if any body measurements, etc. have any correlation with the quantitative variation of sugar in the blood. The motive underlying is to detect such body changes, if any, peculiar to the corresponding quantitative variation of blood sugar in different individual and thereby to establish a *diabetic type* with its peculiar body measurements.

In the present work only one hundred normal Bengali Hindu adult males have been included and the result discussed.

## 37. The development of the head among the Bengalis.

T. C. Ray Choudhury *and* R. N. Basu, Calcutta.

The authors study the length, the breadth, the horizontal circumference of the head and the cephalic index in a developmental series of subjects from the age 17 to age 24 and show that so far as the head characters are concerned, the Bengali students attain their maximum development at the age of 19.

## 38. Language as an aid and obstacle to accurate thinking.

J. F. Bulsara, Bombay.

Since man is essentially a social animal, language arises as an inevitable social necessity at an early stage of human evolution. It is used as an instrument of communication of thought, feeling and ideas, and as such is helpful in developing thinking, expressing feelings and exchanging ideas among members or groups who are acquainted with the meanings of the socially adopted linguistic symbols.

The earlier content of language is concrete and the syntax simpler as is exemplified in the linguistic evolution of the child-mind, but the necessity of expressing and explaining more complicated ideas, and the need of symbolizing abstract notions, of specifying groups, etc. by single linguistic symbols is also felt at a fairly early stage of social development.

Thus language grows and in turn helps to clarify emotions, thoughts and ideas, and communicate them to fellowmen who understand the symbols adopted by the group.

Mind begins to expand, and in individual thinking and mutual talk or conversation linguistic symbols take on various shades of meaning or contents under different contexts of situations.

Thus language is partly affected and influenced by the behaviour, experience and culture of the particular society in which it has habitation

and is a social product, imbibing in its structure the thought and behaviour patterns of the group in which it develops. The defects of logic and reasoning, the imperfect notions about the various aspects of nature and inaccuracies about nature of objects and phenomena gradually evolves to greater and greater precision as the experience and knowledge of the community increases.

The above can be exemplified not only from the language of children and from the language store of simpler peoples, but also from the linguistic habits of the less literate or developed section of an otherwise enlightened community.

A great part of our linguistic behaviour is a matter of habit, and even in an otherwise scientifically-minded community or group, language symbols are used loosely, vaguely or ambiguously. Metaphysics, logic, philosophy, and lastly science have largely been modifying the social usage of language from time to time.

These aspects of looseness, indefiniteness, emotional *affect* and inaccurate implication in the use of language symbols can be easily illustrated in such words as deity, God, spirit, sovereignty, religion, communism, imperialism, etc.

A large part of loose thinking and even inaccurate and unscientific representation in society is due to our linguistic habits and loose language symbols. This defect can only be removed by a greater study of our linguistic behaviour and a deeper analysis of the structure of language and greater care in the use of complex symbols round which have gathered from time to time the emotional re-action of the users and the 'social history' of the community.

## 39. Colour preferences of the Santals.

R. K. MONDAL *and* M. N. BASU, Calcutta.

Experiments were done on hundred adult male Santals of Santal Parganas for determining the relative affective value of colour impressions. In the experiments seven colour papers were taken namely violet, indigo, blue, green, yellow, orange, and red. Testing the colour impressions of the Santals it is found that they have a preference for red. Experiments were done on two other groups of people of India and the results were compared.

In conclusion the authors state that with the present knowledge of psychology racial colour preferences possibly suggest that there may be some inherent psycho-physical differences between the different races of the world.

## 40. The marriage and nishpat customs of the Rishis.

N. DATTA MAJUMDAR, Calcutta.

The 'Rishis' or 'Rishisputras' are the leather-dressing and cobbler caste of Bengal. In this paper, a study has been made of the Rishis of Shahapur (population 1686), a village in the south-east corner of the district of Mymensingh. In the matter of marriage the ordinary rules as to prohibited degrees are followed, and a price has to be paid for the bride.

Widows are not allowed to marry. But the purpose of widow remarriage is served by a peculiar custom known as '*nishpat*' whereby a man employs a widow as a maid-servant, and lives with her as husband and wife without undergoing any ceremony whatsoever. Children born of such an union are not regarded as illegitimate. *Nishpat* sons are entitled to inheritance along with sons of regular marriage, the former getting a share of 6 annas while the latter 10 annas. But the former are esteemed lower in social status than the latter, and are not allowed to sit in the same line with them in social feasts.

The 'nishpat' custom seems to be in an intermediate position between pure and simple concubinage and widow remarriage. The word '*nishpat*' is probably derived from the Sanskrit word '*nishpati*' which may be disjoined as '*ni*' plus '*pati*' that is, one who is without a husband.

## 41. On an improved model of the Profiloscope.

P. C. Mahalanobis, Calcutta.

A photographic profiloscope designed by the author was described in a previous communication to the Indian Science Congress in 1933 and 1936. The accuracy attained in profile measurements on photographs taken with this instrument was discussed in a paper published in Sankhyā, Vol. 3, Part 1 (March 1937).

Further improvement have been made to ensure greater accuracy in seating the subjects in the same standard position. The improved model and photographs taken with it will be exhibited.

## 42. Studies in blood groups in the Khasis.

R. N. Basu, Calcutta.

Blood from 50 individuals were grouped, and the percentage distribution determined and compared with other peoples.

## 43. Marriage ceremonies of the primitive tribes of Travancore.

L. A. Krishna Iyer, Trivandrum.

Marriage ceremonies are common in the savage world. The purposes of their performance are manifold and form a very fascinating study. The joining of hands is found among many savage tribes. It is the outward sign of a troth that the two persons give to each other. Very frequently, it is an act of union. Another wide-spread rite is to eat together. The bridegroom gives a ball of rice to the bride who in turn gives one which he eats. Mutual partaking of food is the strongest of all ties and breaks the most important of taboos, that are prevalent against eating together. Exchange of betelnuts is another custom found among the Malayarayans. The bride gives one half to her lover and chews the other half. They spit in the same spitoon. This consummates marriage. The presentation of a bamboo comb to the bride forms the essential part of the ceremony among the Muthuvans. Another rite is the custom of throwing of some kind of cereals and dried fruit on the couple. It is intended to give food to the evil spirits to induce them to be propitious and depart. Evils are averted from bride and bridegroom not only by positive rites, but also by abstinences of various kinds.

## 44. A prehistoric site within the city of Madras.

M. D. Raghavan, Madras.

In and about the city of Madras are a number of interesting prehistoric sites which await excavation. Practically at the western extremity of the city lies one such site now included in the garden of a house 'Fontenoy'. From time to time Mr. E. Prudhomme, the owner of the property, during the course of building operations had unearthed antique pottery including big sized urns. On his invitation, Mr. Cammiade had inspected the site. His retirement and departure from India prevented a close study being made of it. In August 1934, permission was obtained from the owner, by Mr. T. G. Aravamuthan and the author, on behalf of the Madras Museum to examine and excavate the site.

The site proved to be of more than ordinary interest, not the least remarkable of its features being the great variety of pottery forms met with, the site being closely packed with bowls and pots of black-tipped ware, specimens of all black pottery, large urns of coarse clay and big sized sarcophagi of the Perumbair type. Among the unique forms in pottery are a specimen of all-black bowl with a pointed end, recalling the shape of a half cocoanut with its sharp terminal, a goblet and a censer with fluted stem. The urns fall into three classes—the usual type of large wide-mouthed pyriform urns with the bottom cut flat, such as those found at Adichanallur and Perumbair; the less frequent type with the high neck and mushroom shaped body, and the elongated form with globular body ending in a short stem. Certain of the objects found are highly suggestive of the early Iron Age such as a hoe blade in iron of primitive type and a thick rod of iron. Among other antiquities are a hollow pottery bead and a well made figurine of black pottery in the form of a bird, which possibly are of the nature of votive offerings. Fragmentary pieces of bones found in one of the pots indicate that the people practised what is known as the secondary burial, where the body after a preliminary burial was exhumed, and a selection of bones given a ceremonial interment in cists or sarcophagi with elaborate ceremonials, votive offerings and offerings of food—an extension of the culture discovered in the sites in the neighbouring district, at Pallavaram and Perumbair.

The site was no doubt the burial ground of a settlement of great antiquity which lay in its vicinity; vestiges of which have been collected from the site occupied until a few years ago by the Government brick-fields, extending into the property called Landon's Garden to the north of it. The full extent of the burial site could not be ascertained as the neighbouring areas have been largely built over.

The surface soil is sandy clay, which deeper down changed to the river sand variety. The moisture laden sand was not conducive to the preservation of pottery which softened and fractured, aggravated by the roots of the trees growing on the site.

# SECTION OF AGRICULTURE

*President*:—Rao Bahadur T. S. Venkatraman, C.I.E., B.A., I.A.S., F.N.I.

## General

### 1. Crop insurance for India.

B. Mukherjee, Lucknow.

This paper discusses economic planning of agriculture by crop insurance to minimize the uncertainties of cultivation. The problem is both new and important in a predominantly agricultural country like India.

The enormous advantages of crop insurance to the agriculturist, the consumer and the Government on the one hand, and for industrial development and the organization of agriculture on sound business lines on the other, are discussed.

The difficulties of the scheme are then explained. The actuarial calculation of premia present serious difficulties. There is no general formula which would apply in every case. The provision of storage throughout the country, the lack of telescopic faculty in the cultivator, his limited surplus and heavy debts, these and other difficulties are examined.

The insurance premium would be a tax on surplus while the taxable margin is low. The total cost would be high but it would be largely offset by reduction in other charges for the cultivator. Further, the cost can be minimized in other ways which are explained.

The paper pleads for a modest beginning in the planning of agricultural reconstruction by crop insurance. It also pleads for an enquiry by a Government Committee for framing a practical scheme.

### 2. A new *rabi* crop (sugar beet) for irrigated tracts.

K. I. Thadani, Sakrand (Sind).

The Agricultural Department in Sind is in search of alternative crops for wheat with a view to provide the farmer with crops more remunerative than wheat and at the same time have a wider range of sowing period during the rabi season since wheat, which is at present the predominant rabi crop, has a very limited sowing period. The main idea is to spread out the demand for irrigation water and, at the same time, to increase the area under rabi crops.

Attention was therefore directed to the trial of sugar-beet. An experiment was conducted at the Agricultural Research Station, Sakrand during 1936-37. Five varieties, three from England and two from U.S.A., and four sowing dates, viz. 26th October, 2nd, 9th and 16th November were tested. The seed was sown on ridges at the rate of 4-5 lbs. per acre. The results have indicated that the crop is capable of yielding 250 maunds (80 lbs. a maund) of beets per acre for sugar manufacture and in addition about 300 to 400 maunds of tops for feeding cattle. Early sowing, viz. 26th October, was found to be more satisfactory than later (November)

sowings. The crop is ready for harvest by end of March when the sugar contents reach 13 to 14%. No conclusive results were obtained with regard to the varieties tested. Sugar beet is a five-month crop like wheat, and requires much less water than sugar cane which is a 12-month crop. Taking price of beets at 4 annas a maund, the gross income from the crop will be Rs.62 from which has to be deducted a sum of Rs.15 for extra cost on manure and seed. This leaves a sum of Rs.47 per acre as compared to Rs.30 from wheat. The results, however, require confirmation.

### 3. The use of tender leaves as cattle food.

B. N. BANERJEE *and* G. B. RAMASARMA, Bangalore.

A dozen varieties of leaves that are fed to goats and other cattle, during the dry months of the year, were analyzed for their carotin, protein, calcium, and phosphorus contents. Their nutritive value is high and compares favourably with green grass (*Cynodon dactylon*). They are rich in lime and contain enough phosphorus and protein. The carotin content is also high. Tannins, alkaloids and other bodies, that may act as stomach irritants or poisons, need to be examined in particular cases. The results indicate the possibility of utilizing such vegetation as cattle food in India where the fodder problem is one of major importance.

### 4. Nekalam universal drill.

N. ALAM, Punjab.

The author describes a seed drill of his own invention which is cheap, simple and efficient. It is suitable for sowing most crops. The machine is supplied with either one tined or five tined drills.

### 5. Agricultural meteorology in India.

L. A. RAMDAS, Poona.

The paper discusses the main contributions made in India to the new science of Agricultural Meteorology. The investigations made at Poona on micro-climatology, precision observations, influence of weather on the yield of crops and on the areas sown, the thermal balance and the water balance at the soil surface, methods of influencing climatic environment for given purposes, and evaporation are briefly discussed. Another important subject engaging attention at Poona is the study of the meteorological factors controlling nocturnal cooling of the air layers near the ground. By statistically examining past meteorological data accumulated by the India Meteorological Department, it has been possible to investigate dates of onset of the south-west monsoon, and the frequency of phenomena like heat and cold waves, droughts, floods, hail storms, etc. The possibility of predicting maximum and mimimum temperatures by statistical methods has also been investigated. A number of new instruments have been devised for work on Agricultural Meteorology.

In conclusion the importance of liaison work in connection with issue of warnings to farmers, and training of agricultural workers in Agricultural Meteorology is stressed.

### 6. A new method of determining seepage.

V. I. VAIDHIANATHAN *and* H. R. LUTHRA, Lahore.

A new method has been developed to determine the seepage from canals in waterlogged areas. The method depends on: (i) the determination of subsoil flow by an electrical method, (ii) the determination

of the angle which the outermost stream line of the subsoil flow makes with the vertical, and (iii) the integration of the flow for a cross-section under the canal. The method has been developed in the field in connection with the determination of seepage from a big canal in the Punjab.

## 7. Recent progress of agricultural marketing work in India.

A. M. LIVINGSTONE, Delhi.

*Introductory :* Marketing recommendations of the Royal Commission on Agriculture (1928). Appointment of Marketing Staffs by the Imperial Council of Agricultural Research and by Provinces and States (1935). Commencement of all-India marketing surveys on various important commodities. Nature of surveys and publication of reports.

*Grading and Standardisation :* Need for standardisation owing to the widespread evils of adulteration. Scope of Agricultural Produce (Grading and Marking) Act, 1937. Experiments in grading eggs, fruits, hides, tobacco, etc. Practical difficulties and results showing extent to which enhanced prices of graded produce cover the costs of grading.

Standardisation applied to staple products through Trade Associations. Harmful effects of varying contract terms in different markets. Introduction of standard all-India contracts for cereals and oilseeds. Bearing of standard contracts on 'futures' trading. Need for limited number of representative associations controlling trade terms. Formation of Tanners' Federation, Tobacco Association, etc. Is statutory sanction necessary for such bodies, c.f. East India Cotton Association, Bombay ?

Special position of Indian Central Committees for Cotton, Lac, Coffee, Jute and Sugar and their activities in regard to marketing.

*General Development Work :* Further measures designed to increase the efficiency of distribution and for returning better prices to cultivators. Improved market news service. Advantages of broadcasting and use of vernaculars. Recent advances. Fundamental difficulty of comparing prices in absence of standard all-India weights. Position regarding adoption of a standard tola (180 grains Troy), seer (80 tolas) and maund (40 seers). Elimination of waste by improved methods of storing wheat and the introduction of cold storage and transport for perishables. Multiplicity and variable nature of market charges. Measures to secure uniformity and reduction of high charges. Causes of slow progress in the establishment of regulated markets. Comparative failure of co-operative trading societies due to bad management. Could this be cured by applying some kind of managing agency system to these societies ?

*Conclusions* and probable lines of future development.

# Plant-breeding and Genetics.

## 8. Some aspects of plant breeding in India.

V. G. PANSE, Indore.

Examination of figures for 1934-35 reveals that the area under improved varieties of important Indian crops, except sugar cane is under twenty per cent. While several causes may be responsible for this, it is clear that the great scope for improvement of crops in India is not yet exploited to any appreciable extent. Some suggestions are made for an efficient handling of available breeding material. They include formulation of a clear breeding policy, proper testing of breeding material and the strains evolved by statistically sound methods and examination of the maximum capacity of a strain to respond to selection. The importance of genetic studies in quantitative characters is emphasized.

## 9. An important genetic constant.

N. ALAM, Punjab.

The theory is advanced that for any quantitative character there is a definite relation between the average values of both the parents and any two successive generations. When an algebraic equation is fitted, the sum of the averages of any quantitative character for both the parents and the preceding generation out of any two filial generations, is equal to three times the value of the succeeding one. Thus, if once the values for both the parents and any one generation are known the values for the other generations can be calculated.

## 10. Hybrid vigour in rice.

K. RAMIAH *and* K. RAMASAMY, Coimbatore.

A big population, of over sixty to hundred plants in each $F_1$ of four sets of crosses in rice with parents of varying grain size, was studied for several quantitative characters chief of them being tillering and grain yield. The weight of the crossed seed was found to be bigger only when the female parent had a smaller grain than the male parent. In one cross involving two widely differing parents in grain size, the embryo size was the same both in the selfed and hybrid seed when the bigger grained parent was kept as the mother but was definitely less in the reciprocal cross. Heterosis as measured by tiller production was not directly related to embryo size. The hybrid has a better initial start which, however, is not maintained at the later stages, the initial differences tending either to decrease or increase, thus suggesting that embryo size is not the principal factor accounting for heterosis. It is possible that the endosperm in which the initial embryo is nurtured plays as important a part as the embryo itself.

Heterosis when present generally manifests itself by greater tillering, by larger number of ears per plant, by longer panicles, by earliness in flowering and by larger yield per plant though the amount of such manifestation may vary with particular crosses. Heterosis by increased plant height occurs only very rarely.

## 11. The effect of certain external factors upon the manifestation of hybrid vigour in wheat.

B. P. PAL *and* NEK ALAM, New Delhi.

Hybrid vigour was studied intensively in a cross between Pusa 52 and Pusa 165 wheats under different dates and times of sowing, different depths of sowing and different conditions of spacing. The characters studied were : germination, rate of formation of first four leaves and the first tiller, height of plant, tillering, number of leaves per plant, length of ear, number of fertile and sterile spikelets, number of grains per ear, weight of grain and yield.

The data indicated that the expression of heterosis was greatly influenced by the several external factors studied.

## 12. X-ray mutations in rice.

K. RAMIAH *and* N. PARTHASARATHY, Coimbatore.

The paper deals with a large number of mutations obtained by X-raying rice seed at the Paddy Breeding Station, Coimbatore. Among

the mutations described, thirteen refer to various forms of chlorophyll deficiency of which half a dozen occurring as natural mutations have been described previously. The other mutations refer to different forms of spikelet sterility, grain size and shape, leaf size and type of panicle. $X_2$ and $X_3$ generations have been raised to study the genetics of these mutations. Such studies on the partially sterile mutations show some interesting associations between sterility genes and genes controlling such characters like awning, grain size, flowering duration, size of leaf, stature of plant, and colour of lemma and palea.

Some of the homozygous types isolated from the segregating families are promising economically since they are identical with the original X-rayed parent except for slight improvement in vigour (greater tillering) and small differences in height and flowering duration. Yield trials are in progress to test their usefulness.

## 13. Inheritance of size and shape of grains in rice.

S. K. Mitra *and* P. M. Ganguli, Assam.

The length of spikelets in rice has been observed to segregate in the $F_2$ in the ratio of 3 short to 1 long. The existence of variation within the groups of short and long spikelets can probably be accounted for by minor modifying factors also operating besides the main one.

With regard to the breadth of the spikelets the $F_2$ and $F_3$ frequencies give only normal distribution showing that the inheritance of breadth is of the multiple factor type.

No correlation was found to exist between the length and breadth of spikelets amongst the $F_2$ population of the cross made to study the spikelet size.

## 14. The genetics of Mung (*Phaseolus radiatus* Linn.).

R. D. Bose, Pusa.

Genetical studies in some species of *Phaseolus* such as *Ph. vulgaris Ph. chrysanthus*, *Ph. multiflorus*, etc. have been reported by workers abroad but no genetical results in mung or *Phaseolus radiatus* Linn. (syn. *P. aureus* Roxb.) appear to have been published up to now. The mode of inheritance of colour in the flower, unripe pod, and seed-coat as well as that of quantitative characters such as maturity, length and diameter of pods and the relation of these characters to each other have been studied at Pusa and described in this paper.

The cross was made between Pusa types 18 and 36, the former having dark green, dull seeds, and light yellowish-olive flowers while the latter has pale lemon-yellow coloured seeds with a shining surface and olive-yellow flowers. Monogenic inheritance has been observed in this cross for flower colour and the nature of the seed surface, olive-yellow flowers and shining seed surface (both like those present in type 36 parent) being recessive. Two genes appear to be responsible for the inheritance of the seed-coat colour.

Transgressive segregation has been noted in the maturity of the mung hybrids as well as in the length and diameter of its pods. The colour of the unripe pod has been found to be completely linked with that of the flower whereas there is no linkage between seed-coat colour and the nature of the seed surface nor between any of these two characters and flower colour. Neither there is any relationship between any of the qualitative with the quantitative characters studied.

A correlation of $r = 0{\cdot}50 \pm 0{\cdot}03$ has been observed between the length and diameter of pods but no relations exist between these two characters and maturity.

## 15. Colour inheritance studies in Indian chillies (*Capsicum annuum* L.).

R. B. DESHPANDE, New Delhi.

The paper describes the results of crosses between a yellow-anthered mutant chilli, type 11A, and two Pusa types, type 3 and type 29, the former having purple petals, anthers and nodes and the latter having white petals, purplish yellow anthers and pale purple nodes. The results show that the yellow anthers of type 11A are recessive to the two kinds of purple anthers found in type 3 and type 29 respectively on a monohybrid ratio.

The expression of purple colour in any organ is shown to be dependent on the presence of a factor, *S*, which also determines the purple colour both in anthers and nodes.

The segregation of anther and node colour in relation to petal colour was found to be on a ratio of 36 purple petal, anther and node : 12 white petal, purple anther and node : 16 white petal, yellow anther and green node.

## 16. Cooking tests with Pusa types of pigeon-peas (*Cajanus Cajan* (Linn.) Millsp.).

R. D. BOSE, P. M. GANGULI, *and* S. M. UMAR, Pusa.

The ultimate test for all food crops is their cooking value and hence in all programmes for improvement of such crops the cooking test should occupy an important place. Eighty-six Pusa types of *rahar* (*Cajanus*) and 6 hybrids were tested for their cooking properties and classified into three main groups for taste. This character was correlated with others and it was found that some correlation was present between taste and adherence of husk to the *dal*, colour of the raw and of the cooked *dal* as well as with the time taken to cook. No relationship was observed between the taste of the *dal* and the habit, maturity, flower and pod colours, size and shape of grain, yield, percentage of husk and the consistency of the cooked *dal*.

## 17. The inheritance of basal feathered stigmas (and basal barbed subules) in Sorghum.

G. N. RANGASWAMI AYYANGAR *and* T. VENKATARAMANA REDDY, Coimbatore.

A gene $St_{Bf}$ North Rhodesian in origin, is responsible for the stigmas being fully feathered in Sorghum. $St_{bf}$ results in stigmas whose basal one-third alone is feathered, leaving the top two-thirds of the feathery area devoid of feathers and simply columnar. This restricted feathering has not affected seed setting and has been noted to occur in varieties with gaping glumes. $St_{Bf}$ is a simple dominant to $St_{bf}$. In awned varieties this differentiation in the feathery area shows a parallel effect in the homologous organ, i.e. the subule of the awn. When the stigma is fully feathered, the subule is fully barbed and when the stigma is basal feathered, the subule is basal barbed. The $St_{Bf}$-$St_{bf}$ factor pair behaves in inheritance independent of the sheath colour factors *P* and *Q* and of the grain colour factors $B_1B_2$ and *W*.

This is the first record of a restricted feathered stigma in Gramineæ. This kind of a stigma is a varietal characteristic and is mendelian in inheritance.

## Study of Crops and Crop Products.

### 18. Water requirements of sugarcane varieties during hot weather.

K. L. KHANNA *and* P. C. RAHEJA, Bihar.

Hot weather in North Bihar constitutes a critical stage in the growth cycle of the cane crop. During this period the crop that is usually rainfed has solely to depend upon the water present in the subsoil left over from the previous monsoon while the increasing stress of soil dryness on the crop is relieved only after the next monsoon sets in. The suitability or otherwise of a variety for this tract, therefore, depends largely upon its efficiency to tide over the hot weather. Studies were, therefore, conducted during this period to work out the water requirements of varieties belonging to three distinct groups namely drought enduring, drought escaping and the definitely mesophytic. The results obtained from this field study are summarized below :—

Sugarcane varieties differ widely in their relative efficiency of water requirements and varieties most likely to suit North Bihar tract need have relative efficiency of water requirements equal to or greater than that of 0·33.

A linear proportionality was found to exist between the relative water requirements of varieties and the dry matter produced by them.

A high negative coefficient of correlation was observed between the assimilation capacity of plants and their relative water requirements.

Capacity of varieties to resist drought did not necessarily mean an economical use of water by them.

Degree of development of transpiring surface also did not exhibit any relationship to the relative water requirements of varieties.

### 19. Analysis of certain varietal characteristics in sugar-cane with reference to drought-resistance and yield.

R. N. MATHUR, Shahjahanpur.

The results of a physiological enquiry into certain characteristics of sugar-cane varieties in relation to their drought-resistance and final yield are presented. Thirteen varieties of known performance : (i) drought resistant—Co. 285, 205, 248, Desi and S. 114, (ii) medium resistant—Co. 213, 313, 290, 281 and 331, (iii) drought susceptible—B. 6308, P.O.J. 2878 and Co. 515, were selected and studied for germination, tillering, leaf area, length, width, and water-content, cane height, internode length and thickness, arrowing, final cane yield, sucrose content, etc.

After the monsoon period drought resistant varieties are found to possess usually more than four tillers and the susceptible ones not more than two per plant. The intermediates carry between two and four tillers. High tillering canes are not necessarily heavy yielding; indeed heavy yield is associated with medium tiller production.

Drought resistant varieties are further, average yielders and characterized by thin canes, profuse flowering, narrow leaves with low water-content and low sucrose contents. Susceptibles on the other hand possess thick canes with deficient yield, no flowering, broad leaves with high water-content and high sucrose. Varieties called medium resistant are generally observed to be thick caned, heavy yielding and high in sucrose content ; with respect to leaf width and water-content they occupy an intermediate position.

Certain yield relationships are also included.

## 20. Top/bottom ratio method of determining maturity of sugar-cane.

K. V. S. SATYANARAYANA, New Delhi.

From physiological and biochemical studies, Viswa Nath showed that in a normally grown, ripe sugar-cane crop, the top/bottom ratio method of determining maturity of the cane is the most reliable and least effected by environmental factors.

This paper confirms Viswa Nath's finding and presents data which show that the top/bottom ratio is independent of manurial treatment and gives a correct index of the maturity of the cane.

## 21. Observations on the origin of lint and fuzz hairs in cotton.

V. RAMANATHA AYYAR *and* G. SESHADRI AYYANGAR, Coimbatore.

In a previous paper, it was shown that primordial lint cells could be identified by their characteristic nuclear changes and that hairs were also produced from the sub-epidermal region below the stomata, and these seemed to correspond to the fuzz hairs found on the mature seed-coat. Since then, a large number of cotton varieties were examined for these two types of hairs. All of them confirmed the original observations on the differentiation of hairs. The primordial lint nuclei were found to behave in a manner different from that of mitotic nuclei of the epidermal cells. Studies on the lintless types disclosed that five patterns of lint development ranging from absolute lintlessness to normal lint-formation could be distinguished. In two of them, the primordial lint nuclei were found to disintegrate and in other two, they underwent regularly all the changes, but subsequent growth of the hairs was found arrested, at different levels. Further observations made on the stomatal hairs showed that these are identical with fuzz hairs. They were more clearly brought out on the comparison of ovular sections of naked and fuzzy types which in addition, exhibited a difference in the nature of their stomatal air-cavities.

## 22. Biennial bearing in mangoes.

P. K. SEN, Sabour.

The problem of 'biennial' or 'alternate' bearing in mangoes is discussed and the need for overcoming this difficulty stressed. The cause of the phenomenon and possible methods of control are indicated. It is pointed out that a thorough investigation into the nature and habit of growth of the mango and of factors involved is essential for successful production of the fruit and effectively remedying its biennial bearing.

## 23. Certain metabolic variations and growth rate of Malta oranges.

J. C. LUTHRA, Punjab.

It is recognized that the study of metabolic activities of fruits during their course of development furnishes important data which can be helpful in explaining the changes in the body of ripe fruits exposed to conditions of cold and gas storage. The paper embodies results of an investigation on the respiratory activity, relative growth rate and nitrogen content of developing Malta oranges. It is interesting to note the parallelism between the respiratory activity, growth rate, and nitrogen. They are very high during the adolescent stage and fall off continuously as the fruit ages. The second high value of respiratory activity occurs at the climacteric stage and marks the onset of colour changes in the fruit from green to greenish yellow and finally to orange yellow.

### 24. Effect of 'short' and 'long' day treatment on the flowering duration of different classes of paddy.

M. ALAM *and* A. B. SARAN, Sabour.

An important problem in rice-breeding is the crossing of varieties widely differing in their flowering duration—which is more or less fixed in case of '*Aman*' or winter paddies—and as such it is not ordinarily possible except by utilizing late tillers of the earlier variety. This, however, is not always possible especially when the interval between the flowering duration of the varieties to be crossed is fairly long. Besides this, the setting of grains in such late tillers is also poor. In view of these facts, two sets of experiments were laid to investigate the possibility of altering the flowering duration of the so-called 'timely-fixed' paddy varieties, by (1) increasing, and (2) decreasing the 'day length' artificially. The 'day length' was increased by illuminating the plants with Petromax light during the night, whereas the shortening was effected by removing the plants from full day light to complete darkness.

The effect of both these treatments on the flowering duration of the paddy plants is quite distinct. By increasing the 'day length', flowering date is appreciably delayed, whereas by decreasing it, the plants are induced to flower earlier. The actual shifting of the flowering dates, however, is found to depend on the period for which the actual treatments are given. By adopting one of these methods a definitely 'late' variety has been crossed with a distinctly early one, which was not possible before.

### 25. Physiological studies of salt tolerance in paddy.

M. ALAM *and* A. B. SARAN, Sabour.

The occurrence of large saline areas near the sea coast and also around the Chilka lake in Orissa has rendered difficult the problem of successful growing of paddy which is the only crop that can be cultivated in the tract. Investigations on various aspects of the problem have, therefore, been in progress for the last 3 to 4 years at the Bihar and Orissa Rice Research Station, Sabour. Results of preliminary investigations were communicated at one of the previous sessions of the Congress, but since then a good deal of progress has been made, especially on two aspects of the problem, viz., gradual education of paddy plants to tolerate salinity and pre-treatment of paddy seeds with minute doses of common salt solution before growing them in saline soil.

Results obtained from both these investigations are interesting and point to the possibility of growing paddy in saline areas by either of these methods. Pretreatment of seeds with minute doses of common salt, however, appears to be more promising and is a novel method of solving such problems. The best results have been obtained when seeds are soaked in ·000,000,1% salt solution. Paddy seeds of a non-saline variety soaked in this strength of salt solution were actually grown in saline tracts of Orissa as well as under Pot-Culture conditions, where artificial salinity was induced. The actual data obtained point to the definitely better performance of the treated seeds than the untreated ones.

### 26. Nicotine and its movement in tobacco and in tobacco-tomato grafts.

B. VISWA NATH *and* B. P. PAL, New Delhi.

Nicotine content in different plant-parts of grafts between tobacco and tomato was studied. The tomato scions in grafts where tobacco was used as the stock distinctly showed the presence of nicotine sug-

gesting upward translocation of the alkaloid manufactured in the tobacco stock whereas in the reciprocal grafts the tomato stocks were devoid of nicotine and the quantity of the latter in the tobacco scions was very much reduced.

Nicotine content increased with maturity in the tobacco plants up to a stage after which there was a decline.

## 27. Studies on the storage of potato and its damage by heat-rot.

P. B. SANYAL, New Delhi.

Great damage is done to potatoes in North Bihar during storage through heat-rot. Drastic antiseptic treatments such as dipping in copper sulphate and sulphuric acid solutions, fumigation with $CS_2$, keeping with sulphur, tobacco powder and lime proved ineffective when the mean atmospheric temperature persisted for some time at 85°F. or more.

In two years' storage experiments it was found that smaller tubers preserved better while their dryage was more. Bigger ones are more susceptible to heat-rot. Cultivators sometimes lose as much as 90 per cent. of the crop.

Two factors, viz. high temperature and humid atmosphere, are chiefly responsible for the huge waste of potatoes. Prior to rotting, the tissues first get blackened, then soften and finally a frothing emulsion oozes out. Decrease in albuminoid nitrogen, increase in ammoniacal nitrogen and the formation of dextrine were noticed during rotting.

Respiration of tubers was studied. Respiratory ratio increases with temperature and catalase activity decreases till the tubers suffer injuries in their tissues producing black patches and finally these are attacked with bacteria or fungi producing heat-rot. On cold storage the respiration is slower and injury or blackening of the tissue is much less.

The whole problem of storage of potato, therefore, rests on the avoidance of stimulation to enhance tissue-respiration. This is attained by storing the tubers in cool, fairly dry places. Common air-cooled storage houses in which cold air is admitted at night may serve the purpose. Next best is to store potato on the ground over a bed of sand. It is economical to use small tubers for seed purposes, as they keep better and smaller quantities by weight are required for sowing, while the outturn is the same as from medium or big tubers.

## 28. Potassium ferricyanide method for the estimation of reducing sugars in cane juice.

K. L. KHANNA *and* S. C. SEN, Pusa.

Fehling's method for the estimation of glucose in cane juice is now widely accepted although the necessary use of sodium phosphate filtrate makes it laborious and time-consuming so that where many rounds of analyses have to be completed within the course of each day as is the case in Sugarcane Research Laboratories an accurate yet quick method is a desideratum.

One such method has been found in the direct use of lead sub-acetate filtrate for titration against 1% alkaline Pot. Ferricyanide solution. The method which qualifies the amount of lead sub-acetate to be used for clarifying the original cane juice (2-3 grams for 150 c.c. of cane juice) gives results closely corresponding to those that are obtained with sodium phosphate filtrate by Fehling's and Ferricyanide solutions. The advantage is evident as both the estimations of sucrose and glucose can be done from the same filtrate.

## 29. Properties of jaggery in relation to moisture.

T. Varahulu, Coimbatore.

The responses of good and bad jaggeries to 0·0%, 50%, 60%, 75% and 100% relative humidities were studied. The study revealed several important properties which are so distinctly characteristic of each of the two types of jaggeries studied.

It was indicated that the good jaggeries have a more open texture with capacity to either give up, or take in, moisture readily. They possess a considerable strength of surface, which enables them to hold large amounts of water in surface solution without their structure showing any signs of collapsing. They so characteristically retain but comparatively small amounts of water when at equilibrium in any given humidity below the saturated.

In all these respects the bad jaggeries stand in striking contrast to the good ones.

It was suggested that the moisture content of a jaggery at equilibrium with any given humidity below the saturated might serve as a reliable single value to qualify and evaluate its keeping capacity.

That the water in jaggery might be existing in two forms, viz. as 'free' and 'bound' water, and that the latter might have been held by forces of adsorption, was also suggested.

It was seen that both the good and the bad jaggeries might cease to manifest their hygroscopic tendencies at some humidity which might be lying between 50% and 60% relative humidities.

## 30. New cane varieties from Coimbatore.

N. L. Dutt, Coimbatore.

Attention is drawn to the new varieties of thick canes Co. 419 and Co. 421. The indian cultivator is familiar with the medium canes Co. 213, 285, 290, 313 and 331 which are serving him and the industry so efficiently. The new canes like Co. 419 are different as they contain more of *Pounda* or *Saccharum officinarum* blood.

Co. 419 has, in the trials at the experiment stations in the Bombay and Madras Presidencies as also in Burma and Assam, out-yielded the famous 'wonder-cane' of Java, P.O.J. 2878 and the local canes.

Co. 421 is considered a serious rival of Co. 213 and other medium canes in North India.

Co. 419 thus holds out promise of usefulness for tropical India and Co. 421 for certain parts of sub-tropical India.

# Statistics and Plot Technique.

## 31. Test of significance of treatment means with mixed-up yields in field experiments.

S. S. Bose *and* P. C. Mahalanobis, Calcutta.

In a previous paper, the formulæ for estimating individual yields, in the case of an experiment with two or more plot yields being mixed up, have been worked out by the method of minimizing residual variance. It is shown, in the present paper, how the standard errors of the treatment means may be calculated as a linear function of the known yields in the case of the standard methods of field experiments and how these errors may be utilized for testing significant differences between observed treatment means.

## 32. A complex experiment on winter rice at Dacca farm, 1936-37.

S. HEDAYETULLAH, K. P. ROY, *and* P. C. MAHALANOBIS, Calcutta.

A complex cultural experiment was conducted at the Dacca Farm in 1936 to study the effect of three cultural factors on the yield of a selected strain of transplanted winter rice.

The three factors were : (i) five dates of planting, (ii) six ages of seedling, and (iii) three seedling numbers.

The experiment has shown—

(i) that almost for any date of planting, seedlings of six weeks age give the best results;

(ii) that for early plantings, one seedling gives the highest yield but its superiority to larger number of seedlings diminishes as the planting is delayed. This is true of seedlings two, three and seven weeks old, but the other age groups do not show this difference;

(iii) that there is a decrease of yield for one seedling group in the early August plantings but for the other two seedling groups there are occasional significant increases;

(iv) that in late August plantings 'one seedling' is superior to others and it is due only to two and three weeks old seedlings;

(v) that in early September planting, the yields of one seedling group begin to fall till they are completely superseded in the late September plantings by the local method of planting 3-4 seedlings per hole.

## 33. A complex cultural experiment on rice.

S. C. CHAKRAVARTI, S. S. BOSE, *and* P. C. MAHALANOBIS, Calcutta.

The paper describes the results of a complex four-factor experiment on rice carried in four successive seasons at the Chinsurah Farm between the years 1933–1937. The crop was almost a failure in the third year. Three years' data have therefore been analyzed in this note. The results show that Bhasamanik is the best under Chinsurah conditions, that August 1 is the optimum date of planting and that close spacing and increased number of seedlings per hole are necessary to insure against late transplanting, particularly in a year of adverse rainfall condition.

## 34. A study on tillers of rice plant bearing on their duration of life, performance and death.

K. C. BANERJI, J. R. PAL, *and* P. C. MAHALANOBIS, Calcutta.

With a view to study the mortality of rice tillers in relation to their time of emergence on the mother plant, relevant data were collected from a pot culture experiment in the Bankura agricultural farm. The tillers as they emerged were marked out with a ticket showing the date of emergence and in the event of death the date was inserted on the ticket. The results show that the early tillers contained a greater proportion of grain-bearing tillers than the late ones and that the heavily manured soils always delayed the period of maximum tillering activity compared to the unmanured or light manured ones. It was also found that of the tillers that emerged in the first fortnight of August, 12 per cent were ineffective; those of the second fortnight, 30 per cent were ineffective. Of the tillers of the first part of September, 75 per cent were ineffective while all subsequent tillers were wastes. The contribution to final yield of the tillers of these four periods were respectively 22, 59, 18 and 1 per cent. The question is asked, whether it would be desirable in the interest of high yield to remove all tillers born in the last two periods.

### 35. Preliminary studies on sampling in field experiments.

V. G. PANSE, Indore.

Sampling was tried in several replicated field trials conducted at the Institute and outside to study stand, height, number of fruiting nodes and sheds, and infection by red-leaf and leaf-roll in cotton, incidence of frost in linseed, number of tillers in wheat and barley, and yield in cotton and wheat. Five to ten individual plants or two to five observation rows, each three or four feet long distributed at random in the plot, were employed as sampling units. In linseed half the length of a random row was observed. The sampling adopted was found fairly satisfactory for all characters except yield. It has been shown from a consideration of sampling variance that more extensive sampling by the present or slightly modified methods would ensure greater accuracy.

Sampling can be utilized to the best advantage for taking subsidiary observations rather than for estimating yield and investigations should be concentrated on this aspect of the problem.

## Crop Enemies.

### 36. The relation of Lantana to the spread of spike and a cheap method of eradicating the same.

A. V. VARADRAJA IYENGAR, Bangalore.

Lantana is an exotic which belongs to the family of Verbenaceæ of which the teak is an important member. It has invaded within a few years many provinces and has proved itself a menace. In the Deccan plateau in particular, the development of sylviculturally useful species of plants is seriously threatened. Its cultural characters and nutritive requirements have been studied.

The problem of controlling this vigorously spreading species is considered under three heads: (i) *Removal of the existing crop.* The cover as it occurs to-day in some of the localities represents a wide impenetrable mass of bushes which some times reach to a height of 10 feet and more. In view of its thorny nature, the bush cannot be easily managed. Though the employment of elephants, etc. has been suggested for removing the crop, the process is obviously costly. It has however been possible to control the species through application of chemicals such as sodium chlorate. The results obtained with vast areas of Lantana are discussed. Removal of Lantana through cultural operations has also been considered. (ii) *Elimination of seedlings.* When the existing cover is removed, millions of seedlings arise from the seeds that lie dormant in the soil provided the conditions are favourable for their regeneration. Light and moisture form two more important factors in this connection. Among the many chemicals tried to control the seedlings, thiocyanates were found to be the most potent. (iii) *Control of viable seeds lying dormant in the soil.* Although Lantana can be disseminated through cuttings, root suckers, stump plantings, etc. regeneration through seeds is the most naturally occurring one. Attempts are in progress to treat the soil in a simple way with a view to inhibiting the viability of seeds.

### 37. Sugar-cane mosaic disease in India.

B. L. CHONA *and* S. A. RAFAY, New Delhi.

A brief account of history, distribution and economics of mosaic disease of sugar-cane in India is given.

From fundamental aspect of mosaic virus study regarding physical properties, transmissibility, etc. following points are of chief interest :—

Under Northern India conditions mosaic disease is not doing much damage—the losses being only about 10% reduction in the yield of cane (Co. 213) even in the experimental plots with as high as 60–80% mosaic incidence. Recent tonnage experiments with thick canes have revealed greater losses.

Mosaic virus is not uniformly distributed within the cane as some setts from middle and lower portion of the affected cane give rise to apparently healthy plants ; recovery varying from 0 to 40% depending on the variety.

Thermal death point determinations of mosaic leaf juices of different cane varieties reveal a wide variation between 45°–65°C.

These strongly suggest the existence of more than one mosaic virus strain.

Sugar-cane mosaic virus is sap-transmissible but Chamberland Candle filtrate is non-infectious. It is not seed-transmissible either.

Sugar-cane mosaic virus is rather of a sensitive type, having a low ' thermal death point ', very short life in vitro, inactivation at dilution beyond 1 : 10 and with dilute concentrations of acids and chemicals but does not seem to be affected much with oxidation.

Mosaic virus of any cane variety easily infects other varieties and also maize, jowar (Sorghum) and teosinte (*Euchlaena* sp.). Reverse inoculations, i.e. maize and jowar mosaic leaf juice inoculated into cane have given successful infection.

Season seems to influence greatly the artificial transmission of the disease. Months of May and June at Pusa always gave very high percentage of successful inoculations. Similar seasonal influence has been noticed under Delhi conditions also.

A large number of important sugar-cane varieties have been tested for their resistance to mosaic. Co. 214, 244, 285 and 290 are comparatively more resistant, while Co. 213, 223, 312, 313 and 331 have proved very susceptible.

There are indications of active natural transmission under Coimbatore, Gurdaspur and Jullundur conditions ; to a slight extent at Lyallpur and in traces at Karnal (as observed this year).

P.O.J. 2878, a variety very highly resistant to mosaic has been found badly affected with mosaic at Cuttack, Gurdaspur and Lyallpur.

Control measures.

## 38. Monkeys in relation to agriculture in South India.

T. V. RAMAKRISHNA AYYAR, Coimbatore.

Among the various animals which levy their toll on the South Indian agriculturist, monkeys occupy a fairly important status in many areas of the province ; this is particularly the case in localities situated in the vicinity of hill ranges or along forest areas. Though the writer has very little experience of conditions outside this province they are probably similar in the neighbouring provinces also since we had newspaper reports of monkey trouble in places like Belgaum in the Bombay Presidency. Though in some countries outside India cases have been recorded of monkeys being trained in farms for useful items of work such as fruit picking, coconut gathering, scaring away other pests like crows, etc. etc., in India so far as the writer is aware, the monkey is only notorious for its injurious habits. Anyone visiting places of pilgrimage situated on hills like Tirupati, Palni, etc., can easily convince himself of the acts of mischief and the depredations caused by monkeys to pilgrims in various ways. In this paper an attempt is made to record the writer's experience with monkeys on his small farm and in some of its adjacent villages, all situated along the foot hills of the Western Ghats, in South Malabar. In this brief paper are included notes on the species of monkeys concerned, the nature and extent of injuries caused by them and some of the local methods

adopted to get relief. The main idea of the paper is to get further information if possible from others interested in this subject.

## Soils:

### (A) Physics and Physical Chemistry

39. Some aspects of the 'Anion effect' in the interactions of sodium clays with sodium salts.

RAMPRASAD MITTRA, Calcutta.

The variations of the state of dispersion and cataphoretic velocities (c.v.) of colloidal solutions of sodium clay on the addition of NaCl, $NaNO_3$, $Na_2S_2O_3$, $Na_2SO_4$, $Na_2C_2O_4$, $Na_3PO_4$ and $Na_4Fe(CN)_6$ have been studied. For determinations of the c.v. the micro-cataphoretic method was used and the changes in the state of dispersion of the colloidal solution were followed with the aid of the Pulfrich photometer (Stupho Comparator). While NaCl, $NaNO_3$, $Na_2S_2O_3$ and $Na_2SO_4$ caused a coalescence at all concentrations a marked peptization and a collateral increase of c.v. were observed with $Na_2C_2O_4$, $Na_3PO_4$ and $Na_4Fe(CN)_6$. The peptization and the increase of c.v. were greater the higher the concentration of these salts. Using high concentrations the initial peptization was followed by a gradual aggregation of the particles during which time the c.v. continually increased. At low concentrations this time effect was absent. Sodium ferrocyanide had a marked inhibiting action on the coagulating power of barium chloride which further illustrates its strong peptizing effect. Preliminary work shows that this reagent is a good dispersing agent in the mechanical analysis of the soils so far examined.

40. Studies on the laterite and red soils of India, Part V. A preliminary description of the profile of a few of these soils.

A. T. SEN, Burma.

The profile of soils in some of the laterite areas in Peninsular, Central and Eastern India including Buchanan's laterite soils of Malabar has been examined. A distinction may be drawn between profiles developed under more or less dry weather with evenly distributed rainfall and those developed under alternating wet and dry periods. In the former case red loam seems to be formed as evidence of intense decomposition leading to complete separation of the sesquioxides is absent in the profile whereas in the latter case laterization appears to take place. The profile characteristics of laterite soils in India so far observed are: (i) disintegration and decomposition of rock and soil material to a considerable depth, (ii) light red colour of the soil material in the surface horizon, (iii) slightly acid reaction of the surface horizon passing into neutral or even slightly alkaline reaction in lower horizons, and (iv) a tendency to formation of honeycombed iron crust in the surface horizons.

### (B) Chemistry

41. Analysis of the organic matter fraction of soils and of manures mixed with soil.

C. N. ACHARYA, Bangalore.

The present methods for determining the various fractions of soil organic matter, e.g., Waksman's are shown to be empirical and to yield

results which carry no chemical significance. The methods which have been developed for the analysis of the structural constituents of plant materials e.g., cellulose, lignin, furfural yielding compounds, etc. are found to be not directly applicable to soils and materials containing soils.

The paper reports a procedure for overcoming the interference due to the presence of soil in the estimation of the following fractions of soil organic matter :—(i) Alcohol-Benzene extract, (ii) Uronic acids, (iii) Pentosans, (iv) Cellulose, and (v) Lignin.

Uronic acids are determined by treatment with 12% HCl and estimating the $CO_2$ evolved and making an allowance for the $CO_2$ evolved from carbonates present.

The total furfuraldehyde yield is obtained by steam distillation with 12% HCl in presence of stannous chloride according to the procedure outlined by the author for soils and subsequent precipitation with phloroglucinol. The pentosans are calculated after making an allowance for the furfuraldehyde evolved by the uronic acids present.

Cellulose is determined by alternate extraction of the soil with acid-hypochlorite and alkali-sodium sulphite till no brown colour is obtained on the addition of the latter reagent. The carbon content of the residual soil is determined and the cellulose calculated by multiplying with the factor 2·45.

Lignin is estimated by treatment with 72% $H_2SO_4$ for 15 hours at 15–20°C. and multiplying the residual carbon content with the factor 1·65.

The procedure has been found to yield satisfactory recoveries of added plant constituents. Analytical data for different types of soils and manures are given.

## 42. Comparison of methods for the estimation of furfural yield of soils and manures.

C. N. ACHARYA, Bangalore.

The present paper reports a comparison of the bromine titration method and the gravimetric phloroglucinol method for the estimation of the total furfural yield of soils and manures.

The kinetics of the furfural-bromine system have been examined and it has been shown that Powell and Whittaker's relationship, viz., 1 mol. of furfural = 4 atoms of bromine, at the end of one hour, is empirical and subject to variations due to temperature, concentration of reactants, etc. Powell and Whittakar's method, if carefully followed, gives results agreeing with the phloroglucinol method for plant materials.

In the case of soils and manures mixed with soil, however, low results are obtained by both the methods, due to the presence of oxidizing agents such as ferric and manganese compounds and nitrates in the soil, which apparently oxidize a portion of the furfural during the course of distillation with 12% HCl. The addition of stannous chloride, in regulated amounts, serves to reduce such oxidizing agents and yield the proper recovery of furfural.

In the presence of stannous chloride, however, appreciable amounts of hydroxy-methyl furfural are evolved which go to increase the 'apparent furfural' yield as determined by bromine titration. In the case of phloroglucinol precipitation, the portion of the precipitate due to hydroxy-methyl-furfural can be separated by treatment with boiling alcohol in which it is soluble, and thus correct values corresponding to furfuraldehyde alone could be obtained.

Hence it is concluded that for the estimation of the furfural yield of soils and plant residues or organic manures in the presence of soils the $SnCl_2$—phloroglucinol method is preferable to the bromine titration method.

## 43. A study of the decomposition products of calcium cyanamide in relation to the lag-period during its nitrification in some Indian soils.

N. V. JOSHI *and* H. D. SINGH, New Delhi.

The mechanism of cyanamide decomposition in three Indian soils was studied with particular reference to the cause of the delay that occurs between the accumulation of ammoniacal nitrogen and its conversion into nitrates.

The following conclusions are drawn as a result of this investigation :—

Cyanamide is decomposed completely within about 3 weeks.

Dicyandiamide is formed from one week to three months according to the nature of the soil and contrary to the general belief is not toxic to nitrifying organisms in the concentration in which it is present in soils.

The delay in the oxidation of ammoniacal nitrogen is most probably connected with the water insoluble decomposition products of calcium cyanamide particularly the one which is extractable with 1% HCl.

Dicyandiamide, the most refractory of the water soluble compounds in the soils, is ultimately found to be converted into nitrates.

## 44. Effect of sunlight on the nitrification of ammonium sulphate and oil-cake in the soil. Part II.

D. V. BAL *and* R. S. KRISHNAMURTY, Nagpur.

The observation recorded previously that no nitrification of added organic or ammoniacal nitrogen takes place in soils containing adequate moisture and exposed to sunlight, has been confirmed.

The process of ammonification in the soil, however, continues even when it is exposed to sunlight.

The absence of nitrification is not due to the death of the soil nitrifying organisms but is due to their temporary inactivity as a result of the unfavourable effects produced by sunlight. When soils previously exposed to sunlight are subsequently incubated in the dark, the nitrifying organisms slowly recover from the ill-effects of sunlight and begin to function in a normal manner.

In the case of soils receiving the lower dose of nitrogen, there was neither any appreciable loss nor gain in the total nitrogen content of the soils after they were incubated for a period of 27 weeks (15 weeks of partial sunlight and 12 weeks in the dark). In the case of soils receiving the higher dose, there was however a loss of nitrogen to the extent of 3 to 7 per cent. during the exposure of the soils to sunlight, but no further loss took place when they were subsequently incubated in the dark.

## 45. On the nature of red and black tropical soils.

S. P. RAYCHAUDHURI, Dacca.

In tropical countries, red and black soils occur in neighbouring localities, under apparently the same geological and climatic conditions. From the point of view of soil genesis it is not easy to explain the mechanism of the formation of such soils. A detailed examination of the physico-chemical properties of such soil types at different layers of the profile is necessary. Such investigations were carried out at the Rothamsted Experimental Station with a number of typical soil profiles, kindly supplied by the authorities of the Makwapala and Domira Bay Cotton Stations of the Nyasaland Protectorate of Central Africa. Determinations were made of the silica-sesquioxide ratios and of the contents of free silica,

free alumina and free iron oxide in the clay fractions. The base combining capacities, C/N ratios as also the general physical properties of the soils have been studied. The general conclusion drawn from the above experiments is that although it is not possible to offer an adequate interpretation of the origin of the contrasted soil types, it appears that the major differences are in the state of the organic matter and of the iron compounds. This may be produced by differences in the drainage conditions.

### 46. Usefulness of soil solution examination in plant nutrition problems.

H. N. MUKERJEE, Sabour.

(Through T. J. Mirchandani.)

The availability of plant nutrients from the soil, when it is treated with organic manures (F.Y.M. and Green manures) or is simply heated, is investigated by a detailed study of the soil—soil solution—plant system, for two crops, barley and paddy. Each treatment is judged by two tests of availability : (i) the amount of nutrients appearing in the soil solution, and (ii) the amount of nutrients removed by the crop, the former indicating the power of the soil complex to transfer nutrients to the soil solution, over any length of time, in face of the continuous withdrawal by the plant, and the latter showing the actual amount of nutrients that are available from the point of view of the plant. These taken together have given a complete picture of the whole growth process and provided a basis for the interpretation of the data that might be obtained in the future soil solution studies.

The soil solution was examined for organic nitrogen, ammonia, nitrate, phosphate, (organic and inorganic forms), potash and the analysis was done by the micro-chemical methods. The relationship of the concentration of the soil solution and the plant growth has been established.

The work was carried out at the Imperial College of Science, London.

## (C) Micro-Biology

### 47. Cellulose decomposition by a new organism growing in association with other organisms commonly occurring in soils and manures.

N. V. JOSHI *and* S. C. BISWAS, New Delhi.

During the course of investigation of enrichment cultures made for studying cellulose decomposition from the following materials : (i) rotting paper, (ii) cowdung, (iii) leaf mould manure, (iv) soils from Pusa and Delhi, and (v) horse dung, it was found that the cultures made from single colonies capable of decomposing filter paper in nutrient solution were ' mixed cultures ' developing into yellow or reddish colonies. These mixed cultures would not yield pure cultures when grown on cellulose agar or ordinary agar, but starch agar could separate the mixed cultures into pure cultures which include one organism common to all, associated with either a ' yellow ' or ' red ' growth.

This organism common to all the mixed cultures decomposes cellulose only when growing in association with some other organisms commonly occurring in soils or manures. This peculiarity distinguishes it from other cellulose decomposing organisms.

The morphological, cultural and biochemical characteristics of the organism and the two other organisms associated with it, the products of their metabolism, and the quantitative dissolution of cellulose and nitrogen consumption as well as the nitrogen fixed by it in association with azotobacter, have been studied and described in the paper.

## Manures and Fertilizers

### 48. Rôle of manganese in soil fertility.

C. R. Harihara Iyer *and* R. Rajagopalan, Bangalore.

Previous researches by the authors have shown that chemical oxidizers such as manganese dioxide or permanganate function indirectly as fertilizers in the soil. They hasten the decomposition of organic matter and increase the availability of plant food.

Recent studies have shown that even soluble salts of manganese, such as the sulphate, produce similar effects when applied in moderate quantities. It has been found that the soluble manganese soon passes into the insoluble condition and is present chiefly as the dioxide. The latter occurs in finely divided condition so that the treatment is in some respects even more potent than direct application of manganese dioxide.

These and relevant observations would show that although manganese salts may exert an ionic effect in culture solutions they behave very differently in the soil.

### 49. Dissolution of bone by fermentation of cane molasses.

T. R. Bhaskaran *and* S. C. Pillai, Bangalore.

Studies on the mechanism of dissolution of bone by fermentation with cane molasses have shown that the organic acids formed in the medium react with the insoluble phosphate in bone according to the equation :

$$Ca_3(PO_4)_2+4\times COOH \rightleftharpoons CaH_4(PO_4)_2+2Ca(\times COO)_2$$

Evidence has been adduced to show that the dissolved phosphorus exists in the medium in a water soluble condition.

The main factors that control the adoption of the above principle in the preparation of a water soluble phosphate fertilizer from bone have been studied. It has been shown that the percentage dissolution depends on (i) the particle size of the bone, (ii) the concentration of the acids formed in the medium, and (iii) the reversible nature of the reaction. The products of reaction of the acids with the tricalcium phosphate being largely water soluble does not permit a complete quantitative reaction in the forward direction.

The theoretical significance and the practical importance of the above observations have been discussed.

### 50. Production of the mixed calcium salts of organic acids from cane molasses for fixation of nitrogen in the soil.

T. R. Bhaskaran *and* S. C. Pillai, Bangalore.

Previous studies by the authors have shown that the products of decomposition of cane molasses—chiefly the mixed organic acids—when applied to soil serve as a highly potent energy material for fixing atmospheric nitrogen.

The factors that control the large scale conversion of molasses into these acid products have been studied. A simple method of conducting the fermentation has been described. The procedure consists in mixing molasses with soil and conducting the fermentation in pits under anaerobic conditions. By the above procedure it has been possible to obtain a final product containing 10 per cent. organic carbon. The nitrogen fixed when the product is applied at the rate of 5 tons per acre would correspond to 2 cwts. of ammonium sulphate.

## 51. Experiments on the green manuring of soil with sanai (*Crotolaria juncea*) with its effect on the nitrogen and nitrate fluctuations of the soil and the yield and quality of the succeeding sugar-cane crop.

B. N. PRAMANIK, Shahjahanpur.

The paper deals with sanai as a manure for sugar-cane crop.

## 52. Studies in soil fertility.

A. L. SUNDAR RAO, Allahabad.

In the course of his experiments on the utilization of molasses as fertilizer the author made a systematic study of the physical and chemical properties of soils from fertile and infertile regions of the same tract in cane growing areas.

It was observed that the major chemical constituents did not differ much while the colloid content was different in the two types of samples. Absorption of water vapour was also markedly different at all the relative humidities at which experiments were done. An interesting fact was observed while studying the soil-water relationships viz., that the dehydration of soil colloids was partly irreversible. Soils subjected to alternate heating and wetting lose their powers of absorption of water vapour to a certain extent.

In view of the fact that the importance of trace elements like Mn, Ti, and Zn in promoting plant growth has generally been recognized, a new method of detecting and estimating these trace elements by the Spectrograph has been developed. The arc spectra of many representative soil samples were photographed and examined. Besides the elements which can be detected by chemical analysis as well, the trace elements Zn, Ti, Mn and B could be detected and identified, while Be is suspected in a few. The Mn content of the majority of fertile soils was found to range from 0·04 to 0·15 per cent. while the value of Zn ranged from 0·03 to 0·06 per cent.

## 53. Effect of growing berseem on the nitrogen level in the soil.

T. J. MIRCHANDANI, Sabour (Bihar).

Changes in the soil nitrogen as a result of growing berseem have been studied under the field conditions at Sabour, by analyzing the soil samples every month during the growth of the crop. The two years' work has shown that there is an increase in the soil nitrogen, corresponding to 150 lbs. of nitrogen per acre from October to January and then a gradual fall to almost original level in May. These changes are confined to the first foot, the lower layers were found to be unaffected.

The January sampling corresponds to the second cutting of berseem and the May one to the final (sixth) cutting. The results indicate that the fixation of nitrogen by berseem takes place up to the time of second cutting, after which the crop draws its nitrogen supply from the soil. Dr. Mackenzie Taylor reports similar results from Egypt.

The laboratory observations are supported by the results at the Kanke farm where the soil, after allowing berseem to seed, was so exhausted as to necessitate a manurial dressing in the ensuing season. It was also noticed that a dressing of niciphos to berseem after March produced an extra cut of fodder.

Berseem is finding a place in the general crop rotation in many parts of India but its value as an enricher of soil nitrogen is limited by the observations made in our investigation.

## 54. Plant-food requirements of calcareous soils, Part I. Optimum requirements of phosphorus for Pusa calcareous soils.

S. DAS, New Delhi.

(Communicated by B. Viswa Nath.)

Both pot and field experiments carried out with basal dressings of nitrogen and potash showed that the application of 60, 70 and 80 lbs. of $P_2O_5$ per acre as precipitated calcium phosphate yields the maximum crop production of oats, *ragi* (*Eleusine coracana*) and mustard respectively in calcareous soils and meets the optimum phosphate requirements of these soils for the above crops.

The results obtained were statistically tested and found to be highly significant.

The examination of available phosphoric acid of the soil samples to which were added increasing doses of $P_2O_5$ as precipitated calcium phosphate varying from 25 to 400 lbs. per acre, showed that the values obtained with the author's potassium carbonate method were significantly related to the crop yields of *ragi* up to the limit of 75 lbs. of $P_2O_5$ per acre. Hence 0·0051 per cent. of available phosphoric acid of a calcareous soil resulting from the application of 75 lbs. of $P_2O_5$ per acre corresponds to the maximum crop production.

On the other hand, the values of available phosphoric acid obtained with the Dyer's citric acid method did not yield such significant results as above and failed to corroborate the crop yields.

The examination of the mechanism of assimilation of important food materials by the growing crop from the soil and the fertilizers applied showed that the $P_2O_5$ content of the *ragi* grain increases appreciably with the increasing phosphatic treatment, while the nitrogen content remains almost steady. Its potash content does not, however, show any appreciable variation.

## 55. Responses of sugar-cane to different nitrogenous manures.

P. V. RAMIAH *and* T. VARAHULU, Coimbatore.

The influence of castor cake, farm yard manure, ammonium sulphate and groundnut cake on two cane varieties, Co. 213 and Co. 421 was studied in pot cultures. The indications are : (i) that castor cake and farm yard manure appear to increase the number of tillers and to hasten their formation ; (ii) that ammonium sulphate delays tiller formation ; (iii) that for every variety there appears to be a minimum vegetative growth, before the attainment of which, no tillers would appear, and the magnitude of this minimum varies with treatment, and (iv) that the primary shoot and its tillers exercise a mutual adverse influence on each other's growth. This indicates the desirability of removing the superfluous and late formed tillers, so as to avoid the presence at harvest of canes of widely varying degrees of maturity. Manuring with castor cake and farmyard manure helps to this end. Field scale experiments are proposed to be carried out to verify these indications.

## 56. Value of manuring sugar-canes in Assam.

L. N. PHUKAN, Assam.

A combined varietal and manurial experiment with three varieties viz., POj. 2714, Co. 213 and Teli (a local cane) and three manure treatments viz., no manure, 125 mds. cowdung and 250 mds. cowdung, per acre was conducted for two years both in plant and ratoon canes.

In the plant canes, POJ. 2714 and Co. 213 behaved similarly and were distinctly superior to Teli. The yield of crop increased almost proportionately to the increasing doses of manure.

In the ratoons, Teli was found to be distinctly inferior to POJ. 2714 and Co. 213, as before. Without further manuring, POJ. 2714 and Co. 213 behaved similarly as they did in plant canes but with increasing applications of cowdung, Co. 213 gave significantly higher yields than POJ. 2714. The residual effect of manures was also more prominent with Co. 213 than with POJ. 2714.

The experiment clearly indicated that Co. 213 was more suitable to poor soils and to cultivators who are unable to manure their crop adequately.

POJ. 2714 possesses a higher sucrose content but requires more manuring and is suitable to rich virgin soils and intensive cultivation.

The necessity for manuring the sugar-cane crop is clearly shown whereby the normal yield of the crop in the province can be considerably increased.

# SECTION OF MEDICAL RESEARCH

*President*:—Sir U. N. Brahmachari, Kt., M.A., M.D., Ph.D., F.N.I., F.R.A.S.B.

## 1. Acridin X in the treatment of monkey malaria.

H. E. Shortt *and* K. Padmanabha Menon, Guindy.

An antimalarial drug said to be 'akin to atebrin' was submitted to us by Sir Upendranath Brahmachari for clinical trial in monkey malaria.

A series of experiments was carried out on monkeys infected with *Plasmodium knowlesi* comparing the action of the drug with that of atebrin for injection.

The effect in sterilizing the peripheral blood, the cure rate, and relapse rate of the two drugs were compared.

The results of the experiments showed the two drugs to be identical in their action on *P. knowlesi* and the presumption is that acridin X, if not identical with atebrin, is derived from the same base.

## 2. Treatment of blackwater fever.

K. V. Krishnan *and* N. G. Pai, Calcutta.

The work of Krishnan and Pai on monkey hæmoglobinuria had suggested that at least three conditions have to be satisfied before hæmoglobinuria can occur, namely, a lowering of free-cholesterol, a damage to the liver, adrenals and reticulo-endothelial system and an excessive production of unsaturated fatty acids. On the basis of this theory attempts were made to correct those changes if possible and see how far they influenced the incidence of hæmoglobinuria. Fairly satisfactory results were obtained in monkeys through treatment with a combination of glucose, ascorbic acid and cortin. A combination of choline hydrochloride and quinine also gave encouraging results. It is suggested that these may be of value in the treatment of human blackwater fever. A few preliminary trials have given encouraging results.

## 3. The evolution of and the present position regarding the treatment of hookworm infection.

P. A. Maplestone, Calcutta.

A general discussion is given on the drugs of use in treating hookworm infection, and the history of their introduction is outlined.

The methods of estimating the efficiency of drugs in treating this condition are considered.

The recognized drugs are compared from various points of view, such as efficiency, toxicity, ease in dispensing and price, and the conclusion is reached that tetrachlorethylene is the best if all the above points are taken into consideration.

## 4. A note on the treatment of epidemic dropsy by a stock vaccine containing an organism isolated from the stool.

C. C. Basu *and* Anil Chaudhuri, Calcutta.

The paper deals with epidemic dropsy cases treated with vaccine containing a non-lactose fermenter. The organism was isolated from stool and found to be pathogenic to animals.

The authors report that vaccine treatment with organisms of the salmonella group gives encouraging results in epidemic dropsy cases.

## 5. Treatment of filarial lymphangitis.

S. SUNDAR RAO, Calcutta.

Filarial lymphangitis is a common manifestation of filarial infection in endemic areas and is caused in most cases by secondary infection. In its mildest form the inflammation does not last for more than 2 to 3 days and does not generally call for any treatment. When the attack is more severe it causes acute suffering and in some cases ends fatally. A number of drugs such as carbonactyl, proseptasine and soluseptasine and prontosil have been tried in these cases and the results are reported. The effect of anti-streptococcal serum treatment is also discussed.

## 6. Effect of malarial toxin on filarial infection.

S. SUNDAR RAO, Calcutta.

Observations on artificially induced malaria of both human and monkey strains on filarial patients have been made and the results are discussed. A decrease in the microfilaria-count is noticed immediately after the malarial infection develops in the system but the effect is only temporary. The microfilaria-count reaches its original level as soon as the malarial infection dies out. The significance of the results with respect to the presence of both malarial and filalrial infections in this country is discussed.

## 7. Chemo-therapeutic study on streptococcal infections.

S. P. DE *and* U. BASU, Calcutta.

*p*-amino-benzene-sulphonamide is usually administered in large doses, which is often difficult and sometimes leads to toxic effects. For this, several derivatives of the type, $NH_2 . C_6H_4 . SO_2$ NHR, R = 8-quinonyl, 6-methoxy-8-quinonyl, δ-diethylamino-butylamine and *p*-anisyl, have been prepared and their actions on mice infected with a particular dose of streptococcus hæmolyticus have been studied. But no compound is found to possess a better bactericidal property. The first two derivatives are too toxic, whereas the butylamine derivative has no specific action even *in vitro*. Their acetyl derivatives are less efficacious. This with the observation of Marshall that sulphonamide is partly converted *in vivo* to acetyl derivative possessing a lesser activity indicates that to be an ideal drug, the compound must be R NH . $C_6H_4 . SO_2$ $R^1$, where R would not lower down the efficacy of the drug and $R^1$ would help the compound to exert its full therapeutic effect.

## 8. Chemical constitution and hæmostatic action of coumarins.

P. K. BOSE, P. B. SEN, *and* K. CHAKRAVERTY, Calcutta.

A number of synthetic compounds allied to ayapanin (7-methoxy-coumarin) and ayapin (6 : 7-methylene dioxycoumarin) have been prepared and their effects on the clotting time of blood have been observed. The replacement of methoxy group of 7-methoxy-coumarin by higher alkoxy groups diminishes or completely suppresses the hæmostatic action. Aesculetin dimethyl ether is active but not scopolin. Many other natural coumarins, such as psoralin, angelecin, imperatorin (marmelosin), xanthotoxin, etc. have been found to be devoid of any hæmostatic properties. Ayapanin and ayapin have great possibilities as hæmostatics.

## 9. Some recent observations on the protective value of plague vaccines.

S. S. SOKHEY, Bombay.

Using the standardized quantitative methods recently described by the author for measuring the virulence of strains of *Past. pestis* and for measuring the protective value of plague vaccines further observations have been made. Protective value of broth and agar vaccines has been compared. The effect of temperature of incubation of plague cultures and the effect of temperature of killing cultures on the resultant vaccines have been measured. Heat-killed vaccines made from virulent strains have been compared with live vaccines made from non-virulent strains.

## 10. A new antiplague serum.

S. S. SOKHEY, Bombay.

The preparation of a new antiplague serum is described. New laboratory tests for measuring the value of an antiplague serum have been developed and the results of the animal tests are presented.

## 11. A new antityphoid serum.

H. GHOSH, S. K. BOSE, *and* S. M. MUKHERJI, Calcutta.

An antityphoid serum was obtained from horses immunised with a toxin prepared by culturing *Bact. typhosus* anaerobically in highly alkaline broth. It was found that the serum thus obtained has got a very high agglutinating titre (1 in 8000) presumably due to the presence of a large number of autolyzed bacteria in the toxin. Antityphoid serum was also prepared by injecting typhoid bacillus grown on solid agar. Protection test showed that the serum obtained by immunization with filtered toxin could protect the animal against 3 to 4 minimum lethal doses while the serum prepared with simple typhoid vaccine could hardly protect the animal against 2 minimum lethal doses.

Six cases were so far treated with this antityphoid serum. In the case notes are shown the result of treatment by serum. Only one intraperitoneal injection of 75 c.c. of the serum diluted with 200 c.c. of sterile normal saline was given in each case. In all cases the serum was given on the 10th or 11th day of illness and the temperature became normal on the 16th or 17th day. Toxæmia disappeared entirely after serum injection in each case.

## 12. The applicability of collapse-therapy at the out-patients' section of a city hospital.

A. C. UKIL *and* K. N. DE, Calcutta.

An attempt has been made to estimate the effect and the possibilities of relaxation-therapy in pulmonary tuberculosis as carried on in the out-patients' department of a city hospital. From July 1931 to June 1937 nearly 1,000 cases had undergone artificial pneumothorax, 250 cases phrenic evulsion and 3 cases thoracoplasty.

The paper discusses the difficulties of treating these ambulatory cases and keeping them under control. It has been observed that a fair measure of improvement has been obtained in advanced bilateral cases.

A statistical comparison has been made with the results obtained by sanatorium treatment and it has been observed that nearly 70% of the cases thus treated, showed positive results. Under the circumstances, a plea is made that district hospitals and similar well-equipped institutions

may introduce the modern methods of diagnosis, treatment and follow-up for cases in semi rural and rural areas.

## 13. Herpes Zoster. Experiments with tissue lysate as a therapeutic agent.

L. M. GHOSH, Calcutta.

Forty cases of herpes zoster have been treated with intradermal injections of tissue lysate prepared from the herpetic vesicles and the results have been uniformly successful in relieving the pain and cutting down the duration of the disease. The technique of preparation of tissue lysate is simple and it would be possible to prepare it on a commercial scale.

## 14. Malaria treatment and its effects on the histopathology of the brain in general paralysis of insane.

C. C. SAHA, Calcutta.

The pathological findings in general paralysis of insane (not treated by malaria)—compensatory hydrocephalus, pachymeningitis hæmorrhagica, decortication, frosting of the floor of fourth ventricle, leptomeningitis and perivascular cuffing showing deposit of lymphocytes and plasma cells, degeneration and disappearance of cells of cerebral cortex, presence of spirochætes and paralyse-iron, focal demyelination, neuroglial proliferation and conversion of microglia to rod cells have been described.

Treatment of general paralysis of insane is described with special reference to pyrotherapy specially the malaria inoculation. Modes of infection, course of the infection and its care, dangers, contraindications, results of treatment and its mode of action are also described.

The changes found in the brain after malaria treatment have been described with special reference to the absence of spirochætes and the absence of iron particles.

The possibility of a correlation between these two factors, namely, whether the presence of iron particles is due to the slight continuous hæmolytic activity of spirochætes—direct as in cases of paroxysmal hæmoglobinuria or indirect as in cases of hæmolytic jaundice is discussed.

## 15. Neuro-dermatitis.

G. PANJA, Calcutta.

Clinical features of the disease, its diagnosis, prognosis and treatment are discussed, and a new idea as to its pathogenesis is advanced.

## 16. Allylisothiocyanate in relation to epidemic dropsy.

R. B. LAL *and* S. C. ROY, Calcutta.

(Indian Research Fund Association.)

The authors' previous studies on the ætiology of epidemic dropsy have pointed towards the conclusion that the disease as commonly met with in epidemic form in Bengal, Bihar, and Assam was caused by the ingestion of an unknown poisonous substance, conveyed through the agency of mustard oil.

The problem was approached from three aspects: (1) The loss of allylisothiocyanate suffered by oil in the process of cooking or otherwise heating the oil whether present naturally or added artificially. It was found that ninety per cent. or more of the essential oil was lost. (2) The effects of large doses of allylisothiocyanate, mixed with oil, on laboratory

animals. No symptoms resembling epidemic dropsy were produced by this means. (3) A comparison of the allylisothiocyanate content of the oil used in human experiments and that used by certain families in which no ill effects were observed. The results suggested that the oil associated with epidemic dropsy was not particularly rich in the essential oil. The authors are unable to support the view that allylisothiocyanate was the factor responsible for producing symptoms resembling epidemic dropsy.

## 17. Coronary occlusion.

J. N. MAITRA, Calcutta.

## 18. Allergic diseases and the method of preparing extracts for their diagnosis and treatment.

C. A. ROTHENHEIM, Bombay.

The paper describes various allergic diseases. Diabetes and allergic disease combined in the history of a family are communicated. The manufacturing of allergic extracts for diagnosis and therapy is thoroughly described.

## 19. Observations on scorpion-sting and snake-bite.

U. P. BASU, Calcutta.

The author observes that no death is reported from scorpion-sting in India. He reports 19 cases of scorpion-stings admitted into Calcutta Medical College Hospitals from 1928 to 1937, of which 13 were children below 10 years of age, the mortality being 38·5%. During the same period 27 cases of snake-bite were also admitted between 12 to 45 years of age, twenty of which were viperine and five colubrine. The death-rate was 60%. Comparatively lesser number of admissions of scorpion-stings among adults was due to less severe symptoms in the adults than in children.

Snake-bites manifested classical symptoms of the two types. Scorpion-bites had excruciating pains immediately and some hours following bite and manifested allergic symptoms of headache, giddiness, nausea, vomiting, profuse perspiration with chill, followed often by unconsciousness. The extremities were cold, temperature subnormal, pulse feeble and fluttering, heart sounds muffled. There was fever in some cases. In fatal cases respiration was hurried and majority died from œdema of the lungs. Scorpion was identified to belong to Buthidæ family, Species Tamulus.

In snake-bites local infiltration with gold chloride and Kasauli antivenene intravenously were given. The poisons of different kinds of scorpions differ quantitatively and qualitatively. The present-day treatment of poisons of scorpion-sting and snake-bite is unsatisfactory. The author suggests preparation in India of anti-scorpion serum like 'Todd's Egyptian scorpion serum' and a better form of treatment for snake-bite.

## 20. Study of electrocardiographic tracings of fifty cases of epidemic dropsy.

P. GANGULI, Calcutta.

Electrocardiographic studies of 50 cases of epidemic dropsy show certain interesting variations from normal curves, the most important being that of T waves in the third lead.

## 21. The absence of effective immunity after cure of protozoal infections.

H. E. SHORTT, S. R. PANDIT, K. P. MENON, *and* C. S. SWAMINATH, Guindy.

The opinion of protozoologists is coming more and more towards the conception that the mechanisms of immunity against protozoal infections are essentially the same as those brought into action against bacterial invasions.

The object of the present investigation was to determine whether the relative immunity (premunition) present in chronic or low grade infections with protozoa would disappear completely with parasitic sterilization of the host.

The protozoa experimented with were *Babesia canis*, the cause of tick fever of dogs, *Plasmodium knowlesi* and *Plasmodium cynomolgi*, parasites of monkey malaria.

The plan followed in the experiments was to infect animals with these various parasites, allow some to develop chronic or latent infections and cure the remainder to the degree of complete parasitic sterilization.

The chronically infected animals and those which had been cured were then inoculated with homologous strains of the parasites originally used to infect them and the results compared.

In general it was found that animals carrying latent or chronic infections with the protozoal parasites being investigated were immune to super-infection. On the other hand those which had been cured to complete parasitic sterility had little or no residual immunity and were as susceptible to reinfection as normal animals.

## 22. The rôle of antibodies in kala-azar.

K. V. KRISHNAN, Calcutta.

An investigation was conducted to find out whether the presence of specific antibodies to *L. donovani* was capable of modifying the course of leishmania infection in mice and if so what part these antibodies played in the mechanism of cure and resistance to the infection. The results indicate (1) that antibodies are formed both as a result of inoculation of leishmania vaccine as well as during the course of infection ; (2) that antibodies are capable of lysing extra-cellular leishmania *in vitro* and possibly also *in vivo* but not intracellular leishmania ; (3) that as leishmania are present intracellularly in the body of the host, antibodies fail to destroy them until the host cells are destroyed and the parasites are liberated ; (4) that the evidence suggests that specific antibodies are of some importance in overcoming infection but they do not explain the whole process of immunity and cure in kala-azar.

## 23. Chemical and serological variation in single-cell cultures of *Vibrio choleræ* and related organisms.

R. W. LINTON *and* S. C. SEAL, Calcutta.

(Indian Research Fund Association.)

In continuation of previous work on variation in the vibrios the authors have now made a study of single cell cultures. Beginning with a strain having certain cultural, biochemical and serological characteristics and a certain chemical structure, they have shown that it is possible to produce from it a strain having entirely different characteristics and a different chemical structure. The new strain falls into a different chemical group from the old and its characteristics are those of the new group *in toto*. In other words, the changes which take place are correlated and not haphazard

While variation in chemical structure appears to be fairly frequent in the vibrios, it is to be emphasized that the organisms in variation always remain within the framework of two proteins and three polysaccharides, which are common to the vibrio group as a whole. The conception is that of a strictly limited power of transformation.

Since in the present experiments all the organisms in a given strain were descendants of a single cell, it is suggested that the variants which arose were the result of changes in enzymatic activity within the cells themselves, leading to variations in synthesis of the cellular constituents, and thus to changes in the structure, and in the biochemical, serological and cultural characteristics of the strain as a whole.

## 24. Protein fractions of œdema fluids in epidemic dropsy.

R. N. Chopra *and* S. N. Mukherjee, Calcutta.

The protein concentration in œdema fluids in epidemic dropsy is not high but it is sufficient to confirm the damage of capillary permeability (as concluded from other experiments) in the light of the findings of Salvesen and Linder and Goværts. Both albumin and globulin escape from blood into tissues due to the increased permeability of capillaries, but albumin comes out in greater amount. The globulin to albumin ratio is remarkably constant in the œdema fluid showing thereby that a proportionate amount of globulin always comes out along with albumin. The slightly higher value of this ratio compared to that of aqueous humor in epidemic dropsy glaucoma can be explained. The amount of albumin in œdema fluid cannot account for the loss of albumin from the plasma. It therefore seems probable that albumin becomes depleted in epidemic dropsy by its toxin.

## 25. Adsorption of antigens by antibodies or *vice versa*.

B. N. Ghosh *and* N. N. Ray, Calcutta.

It has been reported by several workers that diphtheria antitoxin concentrated by precipitation with sodium sulphate, does not give flocculation test when mixed with an equivalent amount of diphtheria toxin. This problem has been investigated and a method has been evolved by which such concentrated antitoxin can be made to flocculate. when mixed with an equivalent quantity of toxin in presence of electrolytes. The rate of flocculation of concentrated tetanus and diphtheria antitoxins by their respective toxins at different $p$H has also been investigated. It has been found, that the rate of flocculation is the quickest for the diphtheria toxin-antitoxin mixture between $p$H 6·0 and $p$H 8·0 and for the tetanus toxin-antitoxin mixture between $p$H 5·3 and $p$H 7·2, while above $p$H 10·0 none of these toxin-antitoxin mixtures flocculate.

## 26. The Danysz phenomenon in staphylococcus toxin-antitoxin reaction.

B. N. Ghosh *and* N. N. Ray, Calcutta.

The Danysz phenomenon in staphylococcal toxin-antitoxin reaction has been investigated and it has been found that when the toxin is added to an equivalent quantity of the antitoxin in *two or more* instalments the resulting mixture is highly toxic as measured by its dermo-necrotic as well as, its hæmolytic effects ; on the other hand if the antitoxin is added to the equivalent quantity of the toxin in several instalments, the mixture is non-toxic. It has been further observed that when the resulting mixture is toxic, the toxicity remains unaltered even twenty-four hours after the addition of the last portion of the toxin.

## 27. The chemical nature of tetanus toxin.

D. C. Lahiri, Calcutta.

The possible nature of tetanus-toxin broth was investigated. The lines of approach were: to study the effect of tryptic digestion on the toxicity and antigenicity of the toxin broth; to extract some chemical fractions from it and to study their toxicity and antigenicity; to attempt to grow *Clostridium tetani* in protein-free synthetic medium and to test tho toxicity and chemical nature of the filtrate.

The results were: There was no astounding difference in toxicity and antitoxin production between the digested and the undigested control. No antitoxin was formed from the parenteral administration of various chemical fractions in the rabbits, and they were completely atoxic. Failure of growth in protein-free (amino-acids as well) synthetic media was noted.

Giving due allowance to the difficulties in investigation due to the presence of 'broth' molecules in inseparable conjunction with the 'toxin' molecules the plausible conclusions are—

that the tetanus toxin molecule is not of the nature of a simple protein at least not that protein, which is digestible with trypsin; that the tetanus toxin molecule does not bear a split by the processes of extraction tried in the experiment mentioned, as it loses its properties thereby.

## 28. The effect of seitz-filtration on hemolysins and the components of a hemolytic system.

A. C. Roy, Calcutta.

Seitz filter is extensively used for effecting the filtration and simultaneous sterilization of solutions, culture media and other fluids, where the more drastic methods of sterilization requiring application of heat such as autoclaving, etc. cannot be resorted to. This filter while very effective in producing sterilization in a general way has certain serious limitations. It has been found that dilute solutions of saponins lose their hemolytic property when passed through Seitz filter. Bacterial hemolysins (cholera and streptococcus) are similarly affected. Diluted guinea-pig complement and anti-sheep amboceptor are inactivated by this process of filtration. Concentrated solutions of the active substances are comparatively unaffected. The use of the Seitz filter in investigations relating to bacterial toxins and when dealing with dilute solution is discouraged.

## 29. Observations on differentiating *Bact. coli* and *Bact. aerogenes* types of organisms on Levine's simplified eosin-methylene blue agar as applied to bacteriology of waters in Bengal.

Sukumar Neogi, Khulna.

The author has reviewed the relative significance of the common types of lactose fermenting bacteria found in tropical waters with special reference to the intermediate types.

Levine's modified eosin-methylene blue agar had been employed with a view to differentiating *Bact. coli* and *Bact. aerogenes* simultaneously for confirming the 'presumptive coli' by inspection of colonies on the plates. 966 colonies were tested by this way and the results showed that the differences between these two types of colonies could often be made out after incubation for 48 hours, but the lesser significant intermediate types could not always be eliminated. Out of 642 colonies, tentatively regarded as *Bact. coli* from their appearances on the agar, 483 colonies (75·2%) could be confirmed as such by differential tests and 22·6% was found to be of intermediate types and 3·2% was of *Bact. aerogenes* types. Out of 324 colonies tentatively regarded as *Bact. aerogenes* 231 colonies

(70·0%) could be confirmed as *Bact. aerogenes* types and 70 colonies (21·0%) were of intermediate types.

## 30. Experiments on the spirillum of rat-bite fever.

B. M. Das Gupta, Calcutta.

Experimental rat-bite disease has been studied in man and laboratory animals. Litters born of infected mice have proved negative for spirilla nor did they show any evidence of immunity to infection with the disease. Infection could not be produced in mice by feeding them on urine of infected animals or food contaminated with it for weeks. Adult mice of opposite sex were caged together, the male harbouring the specific parasite. Neither the female nor its offspring was found infected in spite of repeated and careful examinations.

Experimentally infected human volunteers gave consistently negative Wassermann reaction but guinea-pigs infected from these individuals showed positive reaction.

A comparative study on the prevalence of the spirilla in the blood and peritoneal fluid of the infected mice showed that the number of the spirilla in the latter did not diminish to an appreciable extent till the animal died of the disease or of some intercurrent infection; whereas it was subject to marked fluctuation from day to day in the blood from which the spirilla might even temporarily disappear altogether. An attack of experimentally induced rat-bite fever in man proved absolutely refractory to further infection.

## 31. The relation of the parasitic worms of lower animals to those of man, with special reference to fluke infestation.

G. D. Bhalerao, Muktesar.

The paper deals with the trematode infection of man in India and its occurrence in lower vertebrates. It points out the possibility of detecting several hitherto unknown infestations of man in India. The possibility is indicated of dermatitis occurring in man by the schistosome and the stylet-cercaria. Reference is made to the enormous loss suffered by man on account of the fluke infestation of the domestic animals.

## 32. The viability of certain pathogenic micro-organisms in various fresh fruits of India. The viability of *V. choleræ* in water-melon (*Citrullus vulgaris*, Schrad., Tarbuz).

F. R. Bharucha *and* K. H. Bharucha, Bombay.

The coincidence of epidemic diseases with certain fruit seasons in India and elsewhere led the authors to investigate whether Indian fruits could act as carriers of infectious diseases. With this aim in view *V. choleræ* was experimented with on the water-melon. The investigations so far carried out and confirmed over two seasons show that *V. choleræ* can live in the water-melon under experimental conditions as long as four days. The results show that the water-melon may act as a carrier of cholera under Indian bazar conditions.

## 33. Investigation on the bacterial flora of dahi (Yagourt) and the study of inhibitory influence of the different strains of lactic acid bacilli on *Streptococcus*, *Staphylococcus* and *Bact. coli*.

H. Ghosh, S. M. Mukherji, *and* S. K. Bose, Calcutta.

Forty-two samples of dahi from different parts of Calcutta were examined. Various types of lactic acid bacilli were isolated. Pleomor-

phism of these strains of lactic acid bacillus was a very predominant feature. Sometimes bacillary form became coccoid. *Staphylococcus* and *Bact. coli* were isolated along with lactic acid bacilli from many samples of Dahi. Inhibitory influence of these strains upon secondary organisms such as *Bact. coli*, *Staphylococcus* and *Streptococcus* was observed. Most of the strains did not inhibit the growth of these secondary pathogenic organisms. A few of the strains had decidedly inhibitory influence on *Staphylococcus*, *Streptococcus* and *Bact. coli*.

## 34. Studies in filariasis in India.

M. O. T. IYENGAR, Calcutta.

Present knowledge of the distribution of filarial disease and of filarial infection in India is meagre. The relations of the two types of filarial infection, namely, *Wuchereria bancrofti* and *Filaria màlayi* to the causation of filarial disease are discussed. The paper also deals with life histories of the transmitting mosquitoes, the factors which control filarial endemicity and methods of control.

## 35. Distribution of filarial infection in Calcutta.

S. SUNDAR RAO, Calcutta.

Intensive survey of filarial infection in the various wards of Calcutta and suburbs has been carried out. Various factors of infection are discussed in relation to the actual rate of infection found in the different wards. The wards lying on the eastern border of Calcutta are the most heavily infected. The infection is moderate in the wards adjoining the Hooghly river and Central Calcutta. The disease-rate is much higher and the relation between the microfilaria-rate and the disease-rate found in other areas does not hold good. The results of the mosquito survey of different wards are discussed in relation to the prevention of the infection.

## 36. Blood changes in filarial infection.

S. SUNDAR RAO, Calcutta.

Microfilaria rate in cases of elephantiasis is generally very low. The reasons for the disappearance of the embryos from the peripheral circulation in such cases are not clearly understood. The block of the lymphatics in persons with elephantiasis can only partially explain the absence of microfilariæ, as all the lymphatics are not blocked. It is suggested that antibody develops in cases of lymphangitis as a result of destruction of embryos and adult parasites; also as a result of secondary infection. It is possible that changes in the constituents of blood in the affected persons are adverse to the life of filarial worms.

## 37. Study of the Eijkman's test and modification as given by coliform organisms isolated from human fæces.

R. BANERJEA *and* A. K. SEN, Calcutta.

A large percentage of citrate-negative organisms isolated from human fæces fail to give a positive Eijkman's test as carried out with single strength Eijkman's medium.

Double strength McConkey broth seeded with the same organisms and incubated at 44°C. gave a larger number of positive results. Single strength broth however proved unsatisfactory for the purpose of the test.

## 38. Response of the chorio-allantoic membrane of the developing chick embryo to inoculation with various substances, with special reference to *B. proteus* $X_{19}$.

C. G. Pandit, R. Sanjiva Rao, *and* H. E. Shortt, Guindy.

The chorio-allantoic membrane culture technique has been used extensively for the cultivation of filtrable viruses. With some known viruses the interpretation of the results obtained presents no great difficulty but, in dealing with material containing a hypothetical virus, much caution is needed in interpreting the results obtained by this technique. Thus, it has been shown that physical and mechanical injuries may also produce appearances not greatly dissimilar to those which are known to be the product of virus infection. It has even been claimed that such lesions may sometimes be noted in uninoculated eggs. In this connection it may be stated that the authors have themselves isolated bacilli both from the chorio-allantoic membrane and from the heart-blood of chick embryos in uninoculated eggs.

Under these circumstances it was considered essential to study the response of the chorio-allantoic membrane to various substances definitely known not to contain any virus.

The substances employed in this study belonged to very varying categories. There were insoluble substances such as keisulguhr, Indian ink, and aluminium gel; soluble substances such as copper sulphate, sodium chloride, glycerine and starch; species of bacteria and bacterial filtrates, normal and febrile sera, milk, snake venoms, etc. It was found that of the inert substances aluminium gel alone produced lesions. Bacteria, on the other hand, produced lesions not unlike those of virus infections. An attempt has been made to classify these lesions on a histological basis. In a study of lesions produced by bacteria, it was noted that with some, e.g. *B. proteus* $X_{19}$ and *B. typhosus* the lesions produced could be passaged in series by filtrates of the ground lesions obtained through gradocol membranes of $0{\cdot}7\mu$ average pore diameter. The significance of this finding is discussed.

## 39. Occult hæmolytic streptococcal infection as portrayed by antistreptolysin titration.

E. H. Koerner *and* E. P. Poulton, London.

The term 'occult infection' may be used where there is evidence that an organism is associated with a disease; but cannot be cultivated except sometimes in the early stages, e.g. streptococcal tonsillitis. Antistreptolysin titration devised by E. W. Todd and other immunity reactions suggest that acute rheumatism is an occult hæmolytic disease and the same applies to rheumatoid arthritis; we have found that there is a raised titre in about $\frac{1}{4}$ of long-standing rheumatoid cases in a municipal hospital. By using this method in a number of cases of uncertain ætiology the portrayal of 'occult hæmolytic infection' has been attempted. The cases may be grouped according to their most striking manifestation: (1) continued pyrexia, marked or slight, without rheumatic pains and not always after streptococcal sore throat; (2) Erythema nodosum—about half the number tested, the others being due to 'occult tuberculosis'; (3) Purpura (all the 8 cases tested) thrombocytopenic, rheumatic and Henoch's—two associated with acute nephritis; (4) Acute nephritis, 4 or possibly 5 out of 7 cases; (5) complicating other diseases—actinomycosis (1); migratory type 4 pneumococcal pneumonia (1); phthisis and anæmia (1).

## 40. A pathogenic strain of *Staphylococcus citreus* isolated from a case of osteomyelitis.

G. Panja, Calcutta.

## 41. Possibility of identification of extracellular toxin of pathogenic micro-organisms by alum.

H. Ghosh *and* S. K. Bose, Calcutta.

In the course of super-immunization by alum-precipitated toxoid of diphtheria and tetanus the authors observed that the volume of precipitate obtained after addition of alum varied with different samples of toxin. It was also noticed that there was a distinct relationship between the toxicity and the volume of the alum precipitate, i.e. if the toxicity was lower the volume of precipitate was smaller. The experiment was repeated with broth culture filtrate of different pathogenic micro-organisms. It was found that pathogenic micro-organisms, which are supposed to contain only endotoxin, produced very little precipitate with alum. Changing the hydrogen ion concentration did not affect the volume of the precipitate by alum perceptibly. On the other hand, copious precipitate was obtained from filtrate of broth culture of micro-organisms known to produce extra-cellular toxins such as diphtheria and tetanus.

## 42. Some factors controlling the activity of bacteriophage and the method and apparatus for filling medicinal phials with bacteriophage suspension as practised in the Bacteriophage Laboratory, Government of Bihar.

S. K. Chatterjee *and* L. R. N. S. Deo, Patna.

Ch.$\phi$A is the most virulent of all the choleraphages. It is found in the stool filtrate of the majority of the cholera convalescents and is mainly responsible in bringing about a cure. The range of action of the phage should be increased by the process of adaptation. Phage should be administered to the cholera patients as early as possible. Massive dose system gives better result than small dose. In cholera epidemics where Ch.$\phi$A does not act on the causative vibrio, phage treatment is likely to be a failure. After adaptation of Ch.$\phi$A the use of the new phage checks the epidemic at once. Good results of choleraphage treatment in Bihar is mainly due to its rich Ch.$\phi$A content and to the massive dose system.

The method and apparatus for filling ordinary medicinal phials with bacteriophage suspensions as practised in the Bacteriophage Laboratory, Government of Bihar are discussed.

In the authors' process the liquid is filled into the rubber stoppered phials by passing directly into the sterilized drum through filter candles which have been sterilized in the same operation as the drum and its contents (phials).

## 43. Prophylactic value of choleraphage.

A. N. Chatterji, Patna.

In two districts of Muzaffarpur and Purnea in North Bihar choleraphage has been exclusively used for seven years in succession from 1931. During this time which covers the period of a normal cholera epidemic wave in North Bihar, the wells and other sources of drinking water supply were not disinfected and hardly a person was inoculated with anti-cholera vaccine when cholera broke out in the two districts. There has been a remarkable reduction in the quinquennial average cholera death-rate per

1,000 of population during 1931–35 when the districts were treated with choleraphage alone, compared to the previous five-yearly averages from 1900 to 1930.

## 44. Studies of meningococcus bacteriophage.

B. B. Sen, Calcutta.

Meningococcus phage, when kept for one year in contact with serum, i.e. when prepared in media containing serum, does not seem to be deteriorated in action. Action of meningococcus phage is retarded *in vitro* at and above the incubation temperature, though the phage does not die at that temperature. It appears that the meningococcus bacteriophage dies at and above the temperature of 60°C., and that its action is retarded or inhibited *in vitro* at and above the incubation temperature, when it is kept in contact with the living cultures. Thirteen lysable strains were studied. Clinical results tend to show that *in vivo* the meningococcus phage can grow and produce its effects when administered intravenously although subjected to temperatures equal to or above body temperature.

## 45. Investigations into the variations undergone by *V. choleræ* on passage through flies.

R. B. Lal *and* S. C. Ghosal, Calcutta.

Much controversy centres round the question of variability of *V. choleræ*. Some believe that atypical vibrios so commonly met with in the environment and other sources may undergo changes in some of their essential characteristics under certain conditions and may under another set of conditions revert to the original condition. Others hold that the vibrios have fixed characters and that the observed changes are explicable on other grounds. Experiments described here refer to certain changes observed in vibrios by passage through house flies, bred under aseptic condition with regard to gram-negative organisms and bacteriophage. Variations were observed in either direction with regard to metabolic characteristics and chemical constitution of vibrios. These were however not accompanied by other biochemical or serological changes. Significance of these observations from the epidemiological point of view is discussed.

## 46. Sero-positive reaction for syphilis in leprosy.

R. Banerjea, Calcutta.

Kahn's test and Meinicke test of sera from 123 cases of lepers with no history and clinical manifestation of syphilis were simultaneously performed. 42·2 per cent. of these cases gave positive Kahn and 31·7 per cent. gave positive Meinicke reaction. The need for investigating the production of sero-positive reaction for syphilis in non-syphilitic lepers is stressed.

## 47. Studies on the extent of bacterial contamination of the atmosphere of big cities like Calcutta.

H. Ghosh *and* S. M. Mukherji, Calcutta.

Air collected from 29 different places of Calcutta was examined. Generally aerial Staphylococcus, Fungus, Lactic acid bacillus and Coccus, *B. subtilis*, *Chr. prodigiosus*, diphtheroids, etc. were found. The number of pathogenic micro-organisms was found to be very few. Attempt to culture Tubercle bacilli of the air was not successful due to overgrowth of fungi.

Average number of micro-organisms present per litre of air was found to be about 8,375. An individual living in the city of Calcutta inhales about 108,540,000 micro-organisms per day (in 24 hours).

Though most of the micro-organisms are non-pathogenic yet it was found that the autolyzed micro-organisms could produce irritation of the skin after intracutaneous injection.

The work is being continued to determine the seasonal variation of the number and flora of the micro-organisms of the atmosphere of the city of Calcutta and its suburbs.

## 48. Parasites of Anopheles mosquitoes in India.

M. O. T. IYENGAR, Calcutta.

Parasites of Anopheles in India are (1) mites, (2) culicoides, (3) coelomomyces, (4) microsporidia, and (5) mermis. The first-mentioned two parasites are ectoparasitic and do not cause any serious injury to the host. The others which are endoparasites cause fatal results in the infected host. The life-histories of these parasites and their importance in the natural control of Anopheles are discussed.

## 49. On a malarial infection in a paddy-bird.

B. C. BASU, Calcutta.

A plasmodium of the paddy-bird is described. The infection is easily transmitted from one paddy-bird to another by blood inoculation. Sparrows, crows, domestic fowls and canaries are not susceptible to this infection.

The course of the disease is considerably severe, the mortality being 66·6%. After an average incubation period of 7·42 days (varying from 2 to 20 days) the plasmodia appear in the blood, multiply rapidly, are present for 2 to 16 days (average 7·31 days) in the peripheral blood, and then disappear. Some (39·7%) birds died at the height of the infection; some (26·9%) after the plasmodia have disappeared from the peripheral blood and some (33·4%) recovered.

There was no relapse in any case. In majority of the birds which have recovered from the infection there is a solid immunity. Eight old wild birds were refractory to inoculation. A number of young ones were found infected in nature. During the height of infection the internal viscera swarm with the parasites and they disappear simultaneously with their disappearance from the peripheral blood.

Previous records of plasmodia of birds are discussed and it is suggested that the name *Plasmodium heroni* nov. sp. be given provisionally to this organism as the bird is commonly known as ' Pond heron '.

## 50. On the relation of hydrogen-ion concentration of waters to anopheline larval breeding.

S. SESHAGIRI RAO *and* C. ANANDARAMA RAO, Mysore.

It has been generally stated that ' Carrier ' anopheline mosquitoes breed in waters which have a *p*H range from 6·2 to 8·0 whereas certain species have been found to thrive even at very low *p*H readings; but as a rule extremes of *p*H are inhibitory to anopheline larval growth. In this paper the relationship of *p*H values on the anopheline larval breeding has been studied. It has been found that breeding of the larvæ takes place freely in waters of *p*H range of from 7·4 to 8·0. There appears to exist a rather remote relationship between *p*H of waters and the larval intensity as found out by these experiments.

The rôle of other analytical factors on anopheline larval growth is under investigation.

## 51. A contribution to the pathology of cholera.

H. N. Chatterjee *and* S. K. Sen Gupta, Calcutta.

There is very little visible change in the intestinal tract to account for the symptoms of cholera. Changes are outlined in the structure of the bone-marrow, the adrenal, the thymus and the pituitary which indicate a kind of allergic or histamine shock. There is also a hyperplasia of the thyroid gland, the colloid material showing an acid reaction indicating a possible hypofunction. Enlargement of the thymus is a very noticeable feature possibly indicating a somewhat close connection or 'susceptibility' to this acute condition. The disfunction of the kidney seems to be associated with some kind of allergic shock and with the changes produced in the endocrines and in the serum electrolytes rather than to any gross structural change.

## 52. Modern views on the causation of tumours and some observations on the chemotherapy of tumours.

H. N. Mukherjee, Calcutta.

Modern views on the causation of tumours and various chemotherapeutic attempts on cancer along with the writer's own work with tissue oxidisers are summarized in this paper.

## 53. Studies on Van den Bergh's test.

Amulyaratan Chakravarti, Calcutta.

A critical study of the test was done by the writer and the results are stated in the different tables. A large number of clinical cases of jaundice was also studied and the reactions stated.

The writer has shown that bile salts play a very important rôle in the diazo-colour phenomenon. While Sneider and Reinhold's contention is quite correct that higher concentration of bilirubin would give an immediate direct reaction, it does not hold good for all the reactions. Addition of a little bile salts would bring about a prompt direct reaction in a concentration of bilirubin which otherwise would give negative results.

The presence of some amount of hæmoglobin along with bile salts and bilirubin is responsible for the biphasic type of reaction. Delayed direct reaction is very rarely obtained and is due to the presence of bilirubin only and of fairly low concentration. Addition of a little bile-salts or bile or even caffein-soda-salicylas would make the delayed direct to immediate direct reaction.

The writer concludes that (1) there is no ground to assume two types of bilirubin, (2) bile-salts play a great rôle in the development of azo-bilirubin, (3) the colour phenomenon depends as much on the concentration of bilirubin as on other factors leading to quick azotisation. The author considers that the different types of reactions can be explained by a more rational and practical way.

## 54. Pathogenesis and investigation on the pathological gall-bladder.

P. N. Ray, Calcutta.

Cholecystitis is perhaps the commonest cause of surgical dyspepsia in Bengal. The subject is usually a female, about 25 years of age. Females comprise 74 per cent. of the total. 62 per cent. were multiparous.

The infection is usually intramural, being probably blood-borne or carried through the lymphatics from the stomach, duodenum or appendix.

Blood cholesterol was found to vary between 75–175 mg. per 100 c.c. The highest figure was 266 mg. in jaundice. Bile cholesterol seldom exceeded 500 mg.

Of the associated infections appendicitis formed 39, alimentary diseases 46, and puerperal sepsis 31 per cent.

Culture of gall-bladder bile was negative in over 50 per cent. of cases. The organisms isolated were *Bact. coli, Bact. typhosus, Bact. aerogenes lactis* and *Micrococcus catarrhalis*. Culture of the submucous and subserous coats of the gall-bladder and the cystic gland yielded the following organisms, *Bact. coli, Bact. typhosus, B. welchii, Streptococcus viridans, Streptococcus hæmolyticus*, and *Bact. aerogenes lactis*. Samples of fæces were also cultured.

## 55. The bone-marrow studies of kala-azar.

C. C. BASU *and* H. N. CHATTERJEE, Calcutta.

Different stages of the affection of the bone-marrow by the Leishman-Donovan bodies are outlined.

The various characteristic changes in the blood such as the progressive leucopenia and neutropenia as well as the increasing anæmia found in cases of kala-azar are explained in the light of these findings.

## 56. Biological tests for the diagnosis of pregnancy.

F. A. E. CREW, Edinburgh.

Of the many biological inventions that are being employed in the service of mankind, that which is concerned with the recognition of pregnancy in its earliest stages is amongst the most sensational and useful. Its value is such as to make it desirable that it should be included in all programmes for the abolition of maternal morbidity. The routine tests now universally used are biological tests, but it is not improbable that these will give place later to chemical tests and it is to this end that much research is now being directed.

The Friedman, the Aschheim Zondek and the *Xenopus Lævis* tests have different qualities which can be used with advantage in the identification of different physiological and pathological conditions. These tests are best carried out in specially organized laboratories dealing with large numbers. Such laboratories provide unique facilities for research of great promise.

## 57. Erythrocytic studies in anæmia of pregnancy, as a guide to the blood pathology and therapy.

H. N. CHATTERJEE, Calcutta.

Cases of anæmia of pregnancy pass through different phases of blood picture. One and the same case may pass through normocytic, microcytic or macrocytic stage according to the severity of the condition. The prognosis and the therapeutic results of the different stages are discussed in the light of the observations made.

## 58. Hydatidiform mole—a statistical and clinicalt sudy.

P. C. DAS, Calcutta.

The study was undertaken with the idea of ascertaining (1) frequency of occurrence, (2) the effects of (*a*) age, (*b*) parity upon its production, and (3) duration of pregnancy, in Indian subjects particularly Bengalees. The results are compared with similar results collected from European and American literature.

The frequency is worked out from a total of 203,180 pregnancies. In Europe the average frequency is 1 : 2140 whereas in India it is 1 : 361. The greatest number of cases occurred among Europeans in the 3rd decade followed by 4th, 5th and 2nd in order of frequency ; among Indians greatest number of cases were also in the 3rd decade with nearly equal number of cases below 20 and above 31 years. The incidence of average age is 27·3 years (Indian) and 28·9 years (European). It occurs much more frequently in multiparæ, about 88% occurring among Indians. Regarding duration of pregnancy, the longest duration was 25 weeks and the shortest was 4 weeks, the largest number of cases occurring between 12 to 20 weeks. All the cases were treated with manual removal excepting 3 cases. The immediate mortality is 7%.

## 59. The study of the leucocyte counts in the anæmia of pregnancy in Indian women.

H. N. CHATTERJEE, Calcutta.

The hæmatology of anæmia of pregnancy presents an opportunity for studying the physiological correlation between the leucocyte-forming and erythrocyte-forming functions of the hæmopoietic organs. The study reveals that there is a sort of ' threshold ' between the proportions of the two varieties of cells. The effects of secondary complications, confinement, liver therapy and the blood group are discussed. The salient features of the Schilling differential count are put forth and their value in the treatment and prognosis also laid down.

## 60. The problems of carcinoma cervix-uteri in Bengal.

SUBODH MITRA, Calcutta.

In Seva Sadan Women's Hospital in Calcutta during last 10 years (1926-1936), about 8,552 patients were admitted into the gynæcological clinic, of which 921 were carcinoma cervix cases, i.e. roughly every 10th patient was a cancer uterus case.

Next, cases have been geographically mapped out showing that practically every district of Bengal contributes to the number of such cases. Patients have been treated mostly with radium and deep X-Rays and since last four years, operable cases have been treated with radical vaginal operation and post-operative radiation. Cases have been followed up year by year, up to 9 years. End results show 72·7% of 5-year cure in the 1st group, 41%—in 2nd group and 11·1% in the total number of cases. End results have been compared with those of England and the Continent. The end results can be greatly improved if cases are detected early, and adequate treatment given immediately.

## 61. The age order of epiphysial union in Bengalee girls.

S. K. BASU *and* SUDHIR BASU, Calcutta.

The paper is a study of the age at which epiphysial centres unite with the bodies of different bones. The determination of the exact age in the living is of great medico-legal importance. The present work is based on a roentgenographic investigation of the bones round the joints in 130 middle class Bengalee Hindu girls whose exact age was obtained with great accuracy. In selecting the subjects of this series the authors were careful to exclude all cases showing pathological conditions of growth and development. The results arrived at differ from those worked out by researchers in other parts of the world. These differences help to indicate the many factors, e.g. racial, climatic, dietetic, etc. that are responsible for the anomalies in the growth pattern amongst people of various countries.

## 62. A note on toxicology of linseed plant (*Linum usitatissimum*).

K. N. Bagchi *and* H. D. Ganguli, Calcutta.

There were several fatal cases of accidental poisoning of cattle in a village in Bihar and hydrocyanic acid was detected in viscera and stomach-content of some of them. It was ascertained that the animals developed the symptoms of poisoning after grazing in a linseed field when the linseed flowers were fairly mature with the seeds just developed.

A cyanogenetic glucoside—Linamarin—is known to be present in linseed but it is not known if any other part of linseed plant contains this glucoside. The analysis of leaves, flowers, fruits, seeds and also of the oil-cake gives the following result :—

| | |
|---|---|
| Leaves and stems .. .. .. | a trace of HCN. |
| Flowers (before fertilization) .. .. | 0·08% ,, |
| Immature fruits or capsules .. .. | 0·692% ,, |
| Mature fruits (when ready for harvesting) .. | 0·08% ,, |
| Linseed .. .. .. | 0·06% ,, |
| Oil-cake .. .. .. | 0·032% ,, |

It is found that the maximum amount of HCN is obtained by soaking the plant products for about 12 hours in water before distillation while the same treatment with an alkali gives the minimum value. With a dilute acid (0·4% HCl) the yield of HCN is slightly less than that with pure water. It is therefore evident that the enzyme Linase, producing the hydrolysis of this cyanogenetic compound acts best in a neutral medium and its action is retarded by an alkali. The risk of HCN-poisoning appears to depend on the reaction of the gastric juice, the reduced acidity or a neutral reaction helping to bring about a complete hydrolysis of the cyanogenetic compound and to produce the maximum amount of HCN. An alkaline reaction tends to prevent the hydrolysis. An alkali may therefore be regarded as an antidote against linseed-plant poisoning. The investigation is in progress.

## 63. Experiments on the stability of seminal stains from a medico-legal standpoint.

S. N. Chakravarti *and* S. N. Roy, Agra.

During the course of examination of thousands of articles for spermatozoa, it has been found that an unusually large proportion of negative results is obtained in cases of mixed blood and seminal stains and in very old stain cases. To throw light on the underlying causes of this, a series of experiments were instituted which show that while Florence test is given by dry seminal stains even after 100 days, in case of mixed stains Florence test is not given after 44 days, although complete spermatozoa can be detected. In case of wet stains, Florence test is not given even after 48 hours and tails begin to disappear after 10 days and are undetectable after 75 days. These results are highly important and show that too much importance should not be attached to Florence test even as a negative test. These experiments further show that it would be justifiable to declare a positive result if a number of good heads are found.

## 64. Viscosity of mustard oil and its common adulterants.

A. K. Sen, Calcutta.

There is a number of viscosimeters in use in different countries for the determination of viscosity of oils relative to a standard fluid. The

oils tested are those used for lubrication and similar purposes. The Ostwald-Poiseuille apparatus does not appear to be favoured for these tests.

The difficulty of judging the genuineness ot mustard oil from a consideration of its chemical constants has proved a considerable handicap for analysts. The values of these constants are subject to wide variations as different varieties of mustard seeds are used in the manufacture of the oil.

Viscosity being highly characteristic of mustard oil the study of the value relative to distilled water was undertaken and the Ostwald-Poiseuille apparatus was considered to be suitable for this laboratory investigation. As the tubes supplied by the continental makers have a very narrow capillary, good locally made tubes having wider capillaries were tried and were found to give the same results as the imported tubes, provided the flow of water was not too quick and the time could be accurately determined.

The relative viscosity of mustard oil as determined in the Ostwald-Poiseuille apparatus was found to be fairly characteristic and of undoubted value where there were no special tests for the detection of adulterants.

## 65. Application of scientific method to epidemiological research.

R. B. LAL, Calcutta.

While many branches of the medical science have more or less fully developed definite techniques for the elucidation of their unsolved problems, considerable vagueness still surrounds the method of approach in the case of epidemiological research. This is partly due to the great variety and vastness of the problems concerned in epidemiological phenomena and partly to insufficient attention paid by the profession to co-ordinated laboratory and field work. The various mental processes and the general technical methods involved in epidemiological research are discussed and illustrated by their application in recent investigations on epidemic dropsy.

## 66. An epidemic of cholera in a rural area in South India caused by the 'Ogawa' type of *V. choleræ*.

K. V. VENKATRAMAN *and* C. G. PANDIT, Guindy.

(Indian Research Fund Association.)

References to the literature on serological types of *V. choleræ* are given. The Southern districts of the Madras Presidency experienced a severe epidemic of cholera in 1936. The course of the epidemic in one health range and the results of examination of the vibrios isolated at different periods of the epidemic are recorded. In 39 villages with a population of 181,668 there were 2,839 attacks and 1,257 deaths from cholera in 1936. The attack-rate and death-rate have been the highest for several years. Out of 481 deaths investigated, 426 occurred within 2 days after the onset of symptoms, the period in most cases being less than 24 hours.

Of 131 cases examined bacteriologically, *V. choleræ* were isolated from 97. 84 of these were submitted to a full examination. They were all of them typical cholera vibrios, gave positive cholera red reaction, were non-hæmolytic and fermented saccharose and mannose with acid only and did not ferment arabinose. By agglutination and absorption tests, they were shown to be of the 'Ogawa' type. The conclusion drawn is that Ogawa type *V. choleræ* can cause a severe epidemic of cholera.

## 67. A tuberculin-survey in a hill area in the Darjeeling District.

A. C. UKIL *and* S. R. GUHA THAKURTA, Calcutta.

The present investigation was undertaken with a view to ascertain the degree of tuberculization of the people at Kalimpong and its neighbourhood.

A total of 1,650 persons were examined clinically and with Mantoux test, of which 1,152 were males and 498 were females. 91% of these were children. As regards race, 1,163 or the bulk of them were Nepalis, 185 were Lepchas, 135 were Bhutias, 33 were Chinese and others 134. 954 of them were of 'rural' and 694 of 'semi-rural' domicile. A history of previous contact with tuberculosis cases was available in only 7% of cases.

The incidence of total positives, was 44·5%. The incidence among children below 15 years was 38·6% and 55·3% among adults, males giving 40·7% and females 38·9% positives. Rural people showed an incidence of 34·9% and semi-rural 47·4%. Bustee areas showed less infection than the town proper and far-off bazar areas. The Chinese showed the highest incidence, viz., 54·6%. 42·1% of the total reactors gave intense reaction, those belonging to the adolescent age-group showing a comparatively higher incidence. The incidence among contacts was 75·6%, non-contacts showing 37·5% positives. Contacts showed more intense reactions than non-contacts.

A survey carried out by the author in the plains in Bengal, Behar, Assam and Madras showed the incidence of total positives to be almost the same as in a semi-rural area to-day.

## 68. Tuberculosis among home-contacts.

A. C. UKIL, Calcutta.

444 children below 15 years were examined. 343 were in contact with 'open', 27 with 'closed' and 74 with 'unknown sputum' cases. 409 had 'intimate' and 35 had 'distant' contact. Sources of contact were as follows: 'immediate' 313; 'recent' 109; 'remote' 22. Two-thirds belonged to poorer classes.

The percentage of positive reactors varied directly with age. The 'unknown sputum'—contact group showed the highest incidence of infection—85% as against 71% of the total.

Radiological examination revealed healed, arrested and active lesions in 59% of the cases. Thus in 12% of cases, radiological examination failed to detect evidences of infection.

The presence of active parenchymal lesions was detected in 15%—a very high rate. This incidence varied indirectly with age and, in relation to positive reactors, indicated that the younger the age the greater was the risk of disease. In contradistinction to this, it was found that the presence of quiescent lesions varied directly with age.

History elicited over a period of 5 years proved that tuberculosis mortality rate among children of these homes was double that of the general mortality, while in adults it was three and a half times higher.

## 69. Malaria problems in different topographical regions.

M. O. T. IYENGAR, Calcutta.

In the province of Bengal the different topographical regions show considerable variations in the anopheline fauna and in the factors that determine the prevalence of malaria. The conditions prevailing in these regions are discussed in relation to their bearing on malarial incidence and the problems connected with the control of malaria.

## 70. Increase of malaria in Manbhum, 1936.

K. MITRA, Patna.

A short-period Malaria investigation in Sadar subdivision of Manbhum district was carried out in March last. The district for long had enjoyed a reputation of salubrity. Old records show that fever death-rates started increasing from the beginning of twentieth century. Inward population movement started with the opening of the Jharia coalfields (1894). Out of a total population of 1,810,890 persons only 347 per mille are earners or bread-winners. Of the earners 63·1% follow 'ordinary cultivation' and 11·4% in coal industry. 92% of the agriculturists are either tenant cultivators or agricultural labourers. Spleen survey in eight villages were made. Anopheline mosquitoes were found to breed in 'Bundhs' and river-beds. *A. culicifacies*, *A. annularis*, *A. pallidus*, *A. vagus*, *A. fluviatilis* and *A. jeyporiensis* were found prevalent. Scrutiny of Malaria attendance at dispensaries reveal (1) a marked autumn wave starting about a month after the rains set in and a small spring wave in April; (2) greatly enhanced incidence of Malaria in 1936; (3) increased Malaria attendance in dispensaries situated in the neighbourhood of villages with high spleen rates. Interesting feature of the 1936 outbreak was that greatly enhanced incidence of Malaria had no effect on death-rates either due to fever or all causes.

## 71. Some observations on the epidemiology of plague.

S. S. SOKHEY *and* G. D. CHITRE, Bombay.

Using a standardized constant infective dose of plague the resistance to plague of rats from different parts of India has been studied. From this study the fact emerges that there exist in nature strains of rats (Rattus rattus) resistant to plague. During an epizootic and an epidemic of plague in a particular locality susceptible strains die out leaving behind resistant strains. This ends an epidemic. Light is thrown on the possible factors which permit a fresh epidemic to start in that area. The effect of atmospheric temperature on the incidence of plague in a given locality is discussed.

## 72. The action of vitamin C and other reducing substances on certain toxins.

B. GHOSH *and* B. C. GUHA, Calcutta.

Guinea-pigs have been found to be resistant to one m.l.d. of tetanus toxin which was mixed *in vitro* with different amounts of ascorbic acid. The behaviour of other reducing substances like cysteine, glutathione and hydroquinone towards the toxin has been investigated. Similar experiments are in progress with diphtheria toxin.

## 73. Investigation of available carbohydrates in some Bengal food-stuffs.

K. P. BASU *and* MD. ABDUL QUADER, Dacca.

The glucose, fructose, sucrose and starch in eight varieties of pulses and one bazar sample of rice have been determined. Sucrose was estimated by the increase in reducing power after inversion. The glucose/fructose ratio was calculated by solving the simultaneous equations obtained from an iodometric determination and from the estimation of reducing power by Shaffer-Hartmann's reagent.

| | Glucose. | Fructose. | Sucrose. | Starch. | Total available carbohydrate. | Titratable acidity. ml N/10 NaOH 100g. of substance. |
|---|---|---|---|---|---|---|
| | | | | | | c.c. |
| Bengal grm. (cicer Arietinum) .. | ·0735 | ·1115 | ·1720 | 35·890 | 35·785 | 14·685 |
| Soya bean (Glycine Hispida) .. | ·1155 | ·1790 | 2·016 | 18·775 | 21·040 | 23·496 |
| Lentil (Lens esculenta) .. | ·0800 | ·2120 | 1·761 | 50·000 | 52·955 | 17·678 |
| Green gram (Phaseolus Mungo) .. | ·3575 | ·5185 | ·9215 | 47·265 | 49·050 | 20·629 |
| Field pea (Pisum sativum) .. | ·5200 | ·8900 | 3·3560 | 43·015 | 47·815 | 46·990 |
| Arhar (Cajanus Indicus) .. | ·1350 | ·2740 | ·4095 | 49·840 | 50·560 | 35·244 |
| Black gram (Phaseolus Mungo Varr Linn.) .. | ·1275 | ·1790 | ·1505 | 41·150 | 41·625 | 26·443 |
| Khesari (Lathyrus Sativa) .. | ·0850 | ·1710 | ·5195 | 50·145 | 50·915 | 32·356 |
| Rice (Oryza Sativa), (Bazar sample) .. | ·1590 | ·2430 | 2·235 | 71·330 | 74·467 | 10·279 |

## 74. Acid-base balance in some pulses. (Potential acidity.)

K. P. Basu *and* H. N. De, Dacca.

The potential acidities of the pulses Green gram (Phaselous mungo), Field pea (Pisum sativa), lentil (Lens esculenta), Khesari (Lathyrus sativa), Soya bean (Glycine histida) and arhar (Cajanus indicus) have been determined by analyzing their ash constituents. The acidity per 100 gms. is found to be least in the case of green gram (1·77) c.c. N. acid and highest in the case of Bengal gram (4·32) c.c. N. acid. Other pulses possess the values in between these two extremes.

It is concluded, that green gram is superior to the other pulses as regards the acid-base balance of its ash constituents.

## 75. The effect of supplementing the South Indian diet with calcium and phosphorus.

R. K. Pal *and* N. Singh, Coonoor.

(Indian Research Fund Association.)

Typical poor South Indian diets, largely based on rice, are deficient in mineral salts and particularly in calcium. Four batches of 12 young rats, about 50–60 grammes in weight were given a poor South Indian diet consisting of raw milled rice, dhal arhar, black gram, brinjal, amaranth leaves, raw plantain, gingelly oil, coconut and mutton in proportion to adult human daily intake as the basal diet. The second group was given 1·775 grms. of calcium lactate a third, 0·8875 gramme of alkaline potassium phosphate and a fourth, both calcium lactate and alkaline potassium

phosphate, as daily additions to the basal diet. The experiment lasted for 10 weeks, during which their rate of growth was noted. Batches of three animals (males) from each group were kept in metabolism cages for four weeks and intake and excretion of calcium and phosphorus was determined and retention calculated. The same was repeated for groups of three females in each group. At the end of ten weeks the animals were bled to death under anæsthesia, blood from the heart being taken for estimation of serum calcium and phosphorus. A pathological examination of the thyroids and parathyroids was made.

The conclusion is that addition of calcium lactate enhances the nutritive value of Indian diets based on rice. Its effect is slightly increased if alkaline phosphate is added at the same time. The addition of alkaline phosphate alone has no supplementary effect on growth.

## 76. Lesions of peripheral nervous system in vitamin A deficiency.

M. V. Radhakrishna Rao, Coonoor.

(Indian Research Fund Association.)

The peripheral nervous system was studied in rabbits, rats and hens fed on diets deficient in vitamin A and carotene. Clinically, evidences of nervous disorder were rarely observed. Histological examination, however, revealed varying degree of degeneration of the myelin sheaths of the spinal nerves. The significance of the experimental findings as regards peripheral neuritis in the human being is discussed.

## 77. Studies on leprosy and vitamin $B_2$ (G) deficiency.

N. K. Basu, Calcutta.

Diets of patients attacked with leprosy are always poor in protein and vitamin-B complex. It has been found that factor $B_2$ is more prominently absent than $B_1$. A number of early cases of leprosy was treated with vitamin B concentrate from yeast, and the patients with anæsthetic patches showed marked improvement. Afterwards, following the method of Row and his colleagues, nodular leprosy was produced in white mice. In these experimental animals, it was also found that addition of vitamin-$B_2$ had a retarding effect, while its absence in the diet had a favourable effect in the production of the disease. Similarly, animal-protein and fat containing Vitamins A and D were also found to bear some relation to the disease.

## 78. Anti-diabetic factor of vitamin B complex.

N. K. Basu, Calcutta.

Following the usual method, vitamin B concentrate was prepared from yeast. And from this concentrate, a precipitate could be fractionated, which on injection into the rabbits lowered the blood sugar.

Vitamin B concentrate, when administered to diabetic patients, could maintain the level of blood sugar constantly to normal. In these patients, proportion of carbohydrate in their diet could be increased with a parallel increase of vitamin B concentrate intake.

Nature of this precipitate obtained from vitamin B concentrate was compared with all the known factors of vitamin B complex. It seemed to be an entirely new factor in B complex.

This new factor seems to have a specific action on blood-sugar. Nature of its action is discussed in the main paper. In all probability, it not only helps in the metabolism of carbohydrate in the body, but it stimulates the pancreas to secrete insulin, and this is borne out by experiments on lower animals.

## 79. The 'availability' of iron in Indian food-stuffs.

S. Ranganathan, Coonoor.

(Indian Research Fund Association.)

Recent experiments have shown that all the iron existing in food-stuffs, as determined by gross chemical analysis, is not 'available' for hæmoglobin regeneration. Chemical methods, involving the use of αα′ bipyridine, have been evolved to assess the amount of such 'available' iron in biological material, the results obtained agreeing very closely with those obtained by the complicated and time-consuming biological tests. An attempt was made to determine the 'availability' of iron in food-stuffs in common use in India and over 100 of them have thus been examined. Wide variations exist in the 'availability' of iron in the different groups. The iron in cereals is 'available' to the extent of about 40 per cent. while that in pulses is 'available' to a much smaller extent, about 15 per cent. Ragi (*Eleusine coracana*) is an exception in the cereal group in that it has an 'availability' of only 10 per cent. The other food-stuffs do not display any group characteristics.

## 80. 'Available' iron of Indian food-stuffs.

H. Goswami *and* U. Basu, Calcutta.

Sherman, Elvehjem and Hart have shown that the hæmoglobin formation by any iron food is directly proportional to the amount of inorganic iron as determined by Hill's dipyridyl method. It would be of considerable importance for medical as well as public health workers to know not only the total quantity of iron present in any food but the food-stuff that would supply the largest amount of inorganic or rather 'available' iron.

Following Hill's method as modified by Elvehjem and others, the percentages of 'available' iron in rice, wheat, sago, grams, lentil, bitter gourd, mustard, bananas, pistachio nut and tamarind have been determined. Various other vegetables, spices, nuts and fruits are also being studied.

## 81. Phytin-phosphorus content of Indian food-stuffs.

A. R. Sundararajan, Coonoor.

(Indian Research Fund Association.)

Phytin-phosphorus (calcium magnesium salt of inositol hexa-phosphoric acid) has been shown to be poorly assimilated by human beings. The so-called 'anti-calcifying action' of cereals has been explained on the grounds that the poor assimilability of the phosphorus present makes the calcium-phosphorus ratio unsuitable for calcification. The methods of McCance and Widdowson, suitably modified, was employed to determine the phytin-phosphorus content of fifty common Indian food-stuffs. Total phosphorus was also estimated with a view to determining the percentage of phytin-phosphorus. In general, it is found that cereals contain large amounts of this form of phosphorus while most of the leafy vegetables contain none.

Further work is in progress to discover the effect of cooking on the phytin-phosphorus contents.

## 82. Observations on the basal metabolism of Indian boys of six to sixteen years of age in Calcutta.

H. Ellis C. Wilson *and* N. C. Roy, Calcutta.

The data obtained are compared with corresponding figures for European children and inferences drawn as to the significance of climate and diet on metabolism.

## 83. Studies in human metabolism. Retention of nitrogen, calcium and phosphorus and elimination of uric and oxalic acids at different levels of rice intake.

K. P. BASU *and* M. N. BASAK, Dacca.

(Indain Research Fund Association.)

A healthy young man of 18 (weight—48·92 kg.) served as the experimental subject. The following diets at three step levels of rice intake were taken:—

| | Diet I. | Diet II. | Diet III. |
|---|---|---|---|
| Rice .. .. | 200 g. | 400 g. | 600 g. |
| Sago .. .. | 400 ,, | 200 ,, | *Nil.* |
| Dal (Green gram) .. .. | 25 ,, | 25 ,, | 25 ,, |
| Fat .. .. | 25 ,, | 25 ,, | 25 ,, |
| Vegetables .. .. | 200 ,, | 200 ,, | 200 ,, |
| Sugar .. .. | 100 ,, | 100 ,, | 100 ,, |

5 g. of common salt and the same amount of spices were taken each day.

These diets furnished about 3,000 calories per day.

The following table summarizes the results obtained :—

| Diet. | Nitrogen balance in g. | Calcium balance in mg. | Phosphorus balance in mg. | Volume of urine in cc. | Fæcal weight in g. |
|---|---|---|---|---|---|
| I .. | −0·489 | 217 | 443 | 2,146 | 37·58 |
| II .. | +1·368 | 139 | 399 | 2,080 | 36·03 |
| III .. | +2·099 | 56 | 129 | 1,703 | 48·48 |

The nitrogen intake in Diet I, II and III was 3·765 g., 6·275 g. and 8·785 g. respectively.

The calcium intake in Diet I, II and III was 422 mg., 392 mg., and 362 mg. respectively.

The phosphorus intake in Diet I, II and III was 1,375 mg., 993 mg. and 611 mg. respectively.

## 84. The Bengalee schoolboy, his physical development, health and nutrition.

A. CHATTERJI, Calcutta.

The findings are based on the records of 33,151 students.

The value of the biometric average for assessing normality is questioned. The biometric averages are compared with averages obtained from normal students for the same age groups.

The rate of growth of the Bengalee student is considered and the following conclusions drawn :—

(*a*) Total gain in height during this period is 17·16 inches ; in weight 71·48 lbs.; in chest girth 9·68 inches and in vital-capacity 2 litres. (*b*) The maximum rate of growth occurs during the period 11–16, and is particularly marked during the ages 12, 13 and 14. (*c*) There is a sudden fall in the rate of growth after the 16th year. (*d*) Height and chest-measurements are less variable than weight and vital-capacity as criteria of growth and development.

The value of the different methods for assessing normality is discussed.

The value of Ponderal Index, $\frac{\sqrt[3]{\text{Weight in kilo} \times 100}}{\text{Height in cms.}}$, as a nutritional

index considered, its disadvantages are pointed out and a table for weight-height, chest-measurements on a time increment scale worked out to serve as a clinical ready reckoner. A table of annual increments for height, weight, chest-measurements and vital-capacity is given.

The findings of medical inspection are tabulated, the incidence of defective vision, malnutrition, enlarged tonsils, dental caries, enlarged liver and spleen, disease of the heart and lungs and pulmonary tuberculosis are considered.

A survey of the dietetic habits of the Bengalee students is made.

## 85. Pancreatic hormone and its functions.

CHARUBRATA RAY, Calcutta.

Sugar is of prime necessity to the body. When the supply of carbohydrates is adequately maintained pancreatic hormone helps to store up the sugar in the form of glycogen, and it not only inhibits the formation of sugar from other food-stuffs, e.g. proteins and fats but also helps them to carry on their essential rôle of repair and growth. In absence of sugar the check being removed the proteins and fats form sugar to meet the more urgent demand for fuel.

In diabetes—the power of oxidizing sugar is not lost. Deficiency of insulin allows the amino-acids to form sugar in the cells. The absorbed sugar after food does not get accommodation in the cells—there is hyperglycemia and glycosuria. The body does not suffer from want of sugar but from protein inanition. Insulin alleviates the symptoms not by oxidizing sugar. It checks the proteins from breaking down to sugar, so the cells in absence of the sugar accommodates the sugar from the blood. The hyperglycemia and glycosuria disappear and the sugar undergoes normal combustion.

## 86. Glimpses into the practice and principles of medicine in India in the 7th century A.D.

D. V. S. REDDY, Vizagapatam.

It-Ching (635–713 A.D.) during his ten-year stay at Nalanda made a successful study of the science of Medicine. Translated a medical work ' Bhaishajya Vastlu '.

The contents of the book are valuable for medical history. *The philosophical background of the age* : Recognition of the value of health—theory of Karma—belief in ' repetitions ', etc. But medicines and physicians requisitioned as the best and quickest means of getting relief. *Preventive outlook on medicine emphasized* : Elaborate rules of hygiene—(1) Exercises for health, (2) Baths, ordinary and medicinal, (3) Filtering, storing and distribution of water, (4) Foodstuffs, their effects in the body, diets peculiar to different parts of India, cleanliness in the preparation and serving of food, (5) Oral hygiene, tooth sticks and their therapeutic uses, (6) Nasal hygiene. Under *Curative Medicine*, the following topics are discussed : (1) Symptoms of bodily illness, (2) Methods of diagnosis, (3) Theories of causation of diseases, (4) Materia Medica, (5) Therapeutics, general, dietetic and medicinal, (6) Famous and popular prescriptions, (7) Hurtful treatments to be avoided. Interesting sidelights thrown on the social and religious practices connected with ill-health and disease. *Medical Economics. Training of the Physician* : Courses of study and text-books. Social status of the physician. The powers and limitations of the physician.

87. A plea for the promotion of the study of history of medicine in India.

D. V. S. Reddy, Vizagapatam.

*History of medicine.*—' A watch tower from which medicine could be studied as a whole in its developments, tendencies and in all its social implications.' Revival of interest due to ' the efforts of Littre, Daremberg and Sudhoff.

*The problem of historiography.*—The problem in other lands and Universities. Encouragement given to these studies. National and regional Medical Societies, Medical History Clubs, etc. Foundation of Institutes for the History of Medicine, Museums, and organization of exhibitions of ancient (and medieval) medical instruments, books or drawings.

*Neglect of kindred studies in India.*—The Universities should institute courses of lectures. Co-operation between the literary men (the Anthropologist, the Archæologist and Philosopher) and the medical man is necessary for editing texts. Documents and inscriptions throwing light on the epidemics of the ancient and middle ages, or the medical history of great personages or the medical institutións of the period, should be brought to our knowledge. The determination of the dates of the medical writers or of commentators fixing the age of the books, and copying of old breaking-down palmleaf manuscripts are urgently needed. Palæopathological researches on human remains discovered, examination and interpretation of medical antiquities, critical studies on the various classics of different periods should be commenced without delay.

88. Adamantinoma, reporting four jaw cases.

L. S. Ghosh, New Delhi.

These are common tumours of the jaws of long duration associated with the expansion and destruction of the affected bone and often with a history of dental crises and infection. Rarely, the growths which are of dental origin are met with in other situations.

The essential character of an adamantinoma is the presence of cylindrical and stellate epithelium, such as is seen in the enamel organ of the fœtus at the fifth month, in a highly vascular connective tissue stroma. Tissue resembling formed dental elements have been reported in adamantinoma and in one case of those reported here a cementum-like substance is present.

These tumours may occur at any age and in either sex and more commonly in the lower than in the upper jaw. Of the cases reported here, two occurred in male and two in female patients, the ages of the patients being forty-five, twenty-five, twenty-six and thirty, and the duration of the growth, one year, two years, about six months and six months respectively. Only one was an upper jaw tumour.

Adamantinoma frequently recurs after scraping: entire removal of the growth is essential, often necessitating resection of the jaw. Malignant changes of either the carcinomatous or sarcomatous type is a rare and late development, usually associated with a long history of inadequate operative interference.

89. Leucoderma—its ætiology and treatment.

G. Panja, Calcutta.

A discussion regarding the probable cause of the condition given. Treatment with various drugs and their effects described.

# SECTION OF VETERINARY RESEARCH

*President* :—COL. SIR ARTHUR OLVER, KT., C.B., C.M.G., F.R.C.V.S., F.N.I.

## Parasitology

### 1. Schistosomes and Schistosomiasis in India.

G. D. BHALERAO, Muktesar.

A short resumé of the work done so far on the Schistosomes and Schistosomiasis in India has been given. References have been made to the work in connexion with domestic ruminants and equines and an account is given of the important conditions in these animals such as nasal schistosomiasis, ' Gillar ' or ' Phet ' of ovines, nodular portal cirrhosis in enlarged liver of horses, and ' Kumri '. Mention is also made of the description of such species as *Schistosoma indicum*, *S. spindalis*, *Ornithobilharzia bomfordi*, and the nasal schistosome. Work done on the life-history and artificial infection with the nasal schistosome and *S. spindalis* has been stated. The work on the infection of pigs with *S. japonicum* and *S. incognitum* and of dogs with the latter species has been quoted. All the work recorded on the endemic and important human schistosomiasis has been summarized and mention has been made of the speculations regarding human schistosomiasis in India. Mention has also been made of the work done on artificial infection of monkeys and guinea-pigs with *S. spindalis*. References have been cited also to the cercarial fauna of this country, to the use of anthelmintics, and to the metazoan immunity, particularly in connexion with *S. spindalis*.

### 2. Observations on *Bartonellosis* in dogs.

H. N. RAY *and* J. A. IDNANI, Muktesar.

Pyrexia associated with progressive anæmia due to *Bartonella canis* Kikuth infection in dogs has been noted by the authors, and it is suggested that one of the different types of obscure canine fevers in India may be due to this intracorpuscular parasite. Kikuth (1927) and others state that *Bartonella* usually appear in the blood of splenectomized dogs, but in the experience of the present authors this infection was found to be inoculable into healthy unsplenectomized dogs producing acute symptoms and ultimate death of the host in several cases. Symptoms produced by this organism in experimental animals were similar to those observed in canine piroplasmosis, namely, high temperature (up to 105°F), icterus, mucopurulent discharge from the eyes, and progressive anæmia. On autopsy certain gross lesions of the spleen associated with a marked enlargement have been regularly seen, and these are considered at present to be characteristic of *Bartonellosis*.

### 3. The occurrence of air-sac mite, *Cytoleichus nudus* (Vizioli 1870), in fowls in India.

R. L. KAURA *and* S. GANAPATHY IYER, Muktesar.

The occurrence of mites within the air sacs of fowls is recorded for the first time in India. Although primarily parasitic in these sites, an extensive infestation of the organs had developed.

This mite is indistinguishable from *Cytoleichus nudus* (Vizioli 1870), popularly known as the air-sac mite.

On account of the difficulty in treating the affected fowls, it is considered to be a serious condition.

## 4. A form of verminous ophthalmia in equines.

P. R. KRISHNA IYER, Muktesar.

Under the name of 'Periodic Ophthalmia', a disease affecting the eyes of horses in the stud farms at Montgomery and Probynabad in the Punjab has been known for some years. The disease is of a recurrent nature and terminates in the affected animals going blind. The disease occurs at all times of the year, and no seasonal incidence has been observed. Mechanical irritation by flies and dust, bacteria and dietetic deficiency were suspected to be concerned in the causation, but these agents have been eliminated. Histopathological examination has revealed the disease to be of verminous origin, microfilaria being constantly present in sections of the affected eyes, and lachrymal glands. Intense eosinophilia, neutrophile and lymphocytic infiltration and fibroblastic activity are some of the other features seen. The transmitting agent appears to be a biting fly. From the morphological features and unsheathed character, the microfilaria appear to belong to some onchocercoid worm, but attempts at specific determination have so far failed. Experience gained so far tends to show that treatment with antimosan and other antimony preparations have an inhibitory effect on the progress of the condition.

## 5. Cutaneous microfilariasis in Indian cattle.

H. D. SRIVASTAVA, Muktesar.

A peculiar chronic form of skin disease in cattle was encountered at certain places in the Bombay Presidency. Subsequently, a six-year old bullock suffering from the disease was received. When the animal arrived at this Institute it had practically no hair on the greater part of its body, the skin showed numerous scars of healed lesions generalized over the body and from several places pieces of skin had peeled. The skin was very tender and peeled in patches at the slightest injury or abrasion, leaving bright red, bleeding surfaces. Nevertheless, the animal was in good bodily condition and fed well.

Though sections of pieces of skin from the animal revealed the presence of numerous microfilariæ, repeated examination of blood smears and the centrifuged deposits from large quantities of blood proved to be negative for larvæ. However, large numbers of larvæ were recovered from fresh pieces of skin incubated overnight in normal saline at body temperature. The microfilariæ, which are unsheathed, measure 0·252–0·28 mm. in length and 0·004 mm. in breadth. They have a rounded anterior end and a sharply pointed, curved posterior extremity. With the approach of winter the number of microfilariæ in the skin rapidly decreases and finally the larvæ practically disappear from the skin, which appears almost healed, but with the return of the hot season the larvæ and associated clinical manifestations reappear.

There is only one reference in literature to a somewhat similar disease occurring in Japanese cattle described as 'Wahi', 'Kose' or an elephantiasis-like disease by Oguni in 1927. The points of similarity between the Japanese and Indian disease are the seasonal incidence—both flaring up in summer—peeling of pieces of skin at the slightest injury, casting of the coat in patches, and the causative agents of both being unsheathed microfilariæ. The Indian disease differs from the Japanese in the absence of any predisposed sites, nodules in the skin, thickening of the skin at the neck and throat with subsequent development of elephantiasis, and the absence of the microfilariæ in the blood. The disease has been

distinguished from the one caused by *Parafilaria multipapillosa*, and the causative agents have been described.

## 6. Stomach worms in the Indian domestic ducks.

H. D. SRIVASTAVA, Muktesar.

Last year the author reported for the first time the occurrence of members of two spirurid worms—*Acuaria* and *Tetrameres*—in the gizzard and proventriculus respectively of fowls in India. Materials were received from about half a dozen ducks for examination. In every case the proventriculus and gizzard showed the presence of several nodules of varying sizes. On opening the nodules they were found to contain surprisingly large numbers of specimens of a representative of the genus *Echinuria*, besides a little caseous matter. Each nodule has a small opening through which the eggs are discharged into the lumen of the proventriculus and gizzard and are finally passed out with the fæces. The eggs are swallowed by the intermediate host, which according to Hamann, is a water flea (*Daphnia pulex*). The final host acquires infestation by ingesting water fleas containing infective larvæ. The worms penetrate into the wall of the proventriculus and gizzard causing marked inflammation and the formation of nodules which may become large enough to cause mechanical interferences and even obstruction to the passage of food. The birds lose condition, become dull, feathers are ruffled and feeding may become suspended. Sudden death is known to occur. The infestation is serious as no treatment is at present known and prophylaxis is obviously impossible. The paper contains a description of the parasite.

The proventriculus of one of the ducks showed the presence of numerous specimens of *Tetrameres*.

## 7. Occurrence of whipworms and bloodflukes in Indian dogs.

H. D. SRIVASTAVA, Muktesar.

The paper records for the first time the occurrence of whipworms—*Trichuris vulpis*—in dogs in India. The infestation has been observed in about half a dozen cases. The parasite may be responsible for acute or chronic inflammation in the cæcum, rise in temperature and general signs of illness. Remarks on the life-history, pathogenicity and treatments are given.

The occurrence of schistosomiasis due to *Schistosoma suis* in dogs in Northern India is also reported.

## 8. Some unrecorded helminths from Indian ducks and geese.

H. D. SRIVASTAVA, Muktesar.

The occurrence of flukes in Indian domestic ducks and geese has not been recorded up to the present time. The author recovered from ducks received from Peshawar specimens of a monostome, an echinostome and a cestode. The monostome is referable to the genus *Catatropis* and resembles closely *Catatropis indicus* Srivastava, 1934, parasitic in the Indian domestic fowl. The paper contains an account of the three unrecorded parasites.

The occurrence of *Echinostoma revolutum* in Indian geese is also recorded.

## 9. Four new trematodes of the family *Monorchidæ* Odhner, 1911, from Indian marine food-fishes.

H. D. SRIVASTAVA, Muktesar.

Up to the present time only one representative—*Asymphylodora indica*—of this family in Indian hosts has been described by the author

in 1935. In the present paper the author describes a new species of the genus *Proctotrema* Odhner, 1911, and three species referable to two new genera. In one of the two new genera the eggs have a polar filament—a unique feature for the family Monorchidæ. The systematic positions of the new parasites have been determined.

## 10. Four new trematodes of the family *Acanthocolpidæ* Luhe, 1909, from Indian marine food-fishes.

H. D. SRIVASTAVA, Muktesar.

Luhe in 1906 created the genus *Acanthocolpus* for *A. liodorus*, parasitic in the intestine of a fish obtained from Ceylon. Hitherto the genus is represented only by the type species. The paper contains an account of four new species of the genus. The relationships of the four new parasites are discussed. The diagnosis of the genus has been revised, and a key to its species is given.

## 11. Studies on the trematodes of the family *Allocreadiidæ*, parasitic in Indian marine food-fishes.

H. D. SRIVASTAVA, Muktesar.

In this paper nine new trematodes referable as follows, one to the genus *Lepocreoidioides* Yamaguti. 1936, three to *Lebouria* Nicoll, 1909, three to *Opechona* Looss, 1907, one to *Allocreadium* Looss, 1900, and one to a new genus are described. In its systematic relationship the new genus stands between the true Allocreadid trematodes and members of the Opecaelinæ. It resembles the latter sub-family in the character of the male genital ducts. The relationships of the new parasites have been discussed in detail.

## 12. Two new genera of digenetic trematodes from Indian hosts.

H. D. SRIVASTAVA, Muktesar.

Two new trematodes referable to the families *Zoogonidæ* and *Acanthostomidæ* are described. They were found in the gut of Indian marine food-fishes. The representative of the former family is characterized by the topography of the gonads, extent of intestinal cæca and cirrus sac and the peculiar shape and position of the vitellaria. The peculiarities of the form assigned to the family *Acanthostomidæ* are the presence of a peculiar bell-shaped vestibule in front of the oral sucker, presence of two ani, and the character of the ovary. The relationship of the two genera with the allied forms has been discussed.

## 13. Verminous pneumonia in Indian buffaloes.

H. D. SRIVASTAVA, Muktesar.

Verminous pneumonia in domestic animals is one of the most serious and outstanding of parasitic diseases for which no satisfactory method of treatment or prevention is known. Apart from the larvæ of certain roundworms which pass through the lungs during their course of migration in the body, there are several worms which have their final habitat in the lungs. Amongst the ruminants representatives of four genera of lungworms—*Dictyocaulus*, *Protostrongylus*, *Muellerius* and *Varestrongylus* are found. *D. viviparus* occurs in the bronchii of cattle while *D. filaria*, *P. rufescens*, *M. capillaris* and *V. pneumonicus* occur in the lungs of sheep and goats. Representatives of the genus *Protostrongylus* are so far known to occur in the lungs of goats and sheep only. A piece of a lung from a buffalo was received which on examination revealed the presence of

several specimens of an interesting representative of the genus *Protostrongylus*. The worms were associated with pneumonia in the piece of lung. In literature the occurrence of lungworms in buffaloes has not hitherto been recorded. A description of the species of *Protostrongylus* responsible for causing pneumonia in Indian buffaloes is given.

## Protozoology

### 14. Surra in Hyderabad State.

M. R. MAHAJAN, Hyderabad.

In this paper are recorded observations made in the State since 1932. Surra in solipeds is being treated with a single injection of Naganol given intravenously in a ten per cent. solution. A success of 75 per cent. is recorded, 25 per cent. having relapsed due probably to Naganol failing to sterilize the cerebrospinal fluid in cases that were in the advanced stage of the disease.

Surra in the bovine is recorded in acute form especially in bullocks when they are worked hard during the early winter months. Field experimental work undertaken to study the *Trypanosoma* concerned gave indications of this being only *Trypanosoma evansi*, the view being supported by the Imperial Veterinary Research Institute, Muktesar. In the treatment of bovine Surra, Naganol in a ten per cent. solution given intravenously is advised in early stage, but in the acute and fatal stage Tartar emetic is recommended.

In regard to the vector problem the author records the findings of viable trypanosomes, and *Crithidia tabani* in the fly *Tabanus rabidus*.

*Trypanosoma theileri* was recovered for the first time in Hyderabad, its identity being confirmed by the Imperial Veterinary Research Institute, Muktesar.

Mention is also made of the occurrence of Surra in the camel.

### 15. Rhinosporidiosis in bovines in the MadrasP residency, with a discussion on the probable modes of infection.

M. ANANTNARAYAN RAO, Madras.

The author notes that the number of cases of rhinosporidiosis in animals, reported from various parts of the world, is small and those reports refer to three equines in South Africa and one in Uruguay. A few years ago the disease affecting two bullocks, one cow and one pony was recorded in the Madras Presidency. Since then the disease has been diagnosed in eighteen bullocks and one pony in the same province. It would seem that rhinosporidiosis in bovines has been reported so far only from the Madras Presidency and from no other part of the world.

It is observed that in animals, just as it is in a large majority of human beings, the lesions are found in the nose, and the presence of a trauma in the nose appears to be necessary for the development of the lesions. In the Madras Presidency, the disease is found affecting both men and animals in certain districts. Rhinosporidium has not been reported from animals from North India, though it has been reported to affect the human beings in certain provinces.

The author has discussed in his paper the resemblance in the histopathology, etc. of the lesions in man and animals and suggests that the causal organisms may be identical in them. While describing the contents of the asci of rhinosporidium, the author suggests that the large spores may be analogous to seeds of plants and are meant to complete their biological destiny outside the animal body. He suggests that those spores may germinate in manure into a saprophytic fungus whose end products are infective to healthy animals, since direct transmission with

the large spores from the lesions is not possible. It is also suggested that the small-sized spores, which were hitherto considered as undeveloped ones, are really not so, but they are meant to continue the parasitic phase in the tissue of the host.

Some amount of success is claimed in cultivating the fungus in sterile cowdung and the author suggests that the infection to man and animals may be through dust raised while ploughing fields manured with bovine dung, since a large number of cases of rhinosporidiosis are met with in men and animals engaged in agriculture. The probability of the infection being water-borne is also discussed. The paper is illustrated with some photomicrographs of lesions, etc. from bovines and equines.

## 16. Rhinosporidiosis in equines. Record of another case in India.

LAKSHMI SAHAI, Patna.

In this paper the author records the discovery of another case of rhinosporidiosis in equines in India in a country-bred mare at Bargarh in the Sambalpur district of Orissa, the first case having been recorded by Krishnamurti Ayyar in Madras in 1932.

The animal, which had a noisy breathing and blood-stained mucous discharge oozing from one of the nostrils, on examination showed a small cauliflower-like growth about 1 inch long and ½ inch thick situated in the anterior part of the nasal chamber slightly obstructing the passage.

On histological examination the growth revealed all the essential features of rhinosporidiosis recorded by Krishnamurti Ayyar in the case from Madras.

Underlying the covering stratified squamous epithelium in the superficial layers of the highly vascular subjacent connective tissue were present numerous cysts or sporangia in various stages of development, the fully mature ones being seen to increase in size, approach the surface and burst to discharge the spores.

It is suggested that further systematic search may perhaps reveal the presence of many more cases in other parts of India, a subject of some importance in view of the close connection between and possible identity of *Rhinosporidium equi* and *Rhinosporidium seeberi*, the causal parasite of Rhinosporidiosis in man.

## 17. Experiments on the transmission of Surra (*Trypanosoma evansi* infection) through the agency of *Ornithodorus papillipes* Birula, with remarks upon the bionomics of this tick.

S. K. SEN, Muktesar.

Cross and his collaborators (1921-22), in the Punjab, recorded having successfully reproduced surra in laboratory animals through the agency of the tick *Ornithodorus papillipes* and also postulated the occurrence of a cyclical development of the surra parasite within the tissues of this tick. The present experiments were undertaken to obtain confirmation of their findings, a supply of ticks for this work having been received through the courtesy of the Principal of the Punjab Veterinary College. A total of 502 ticks were fed on guinea-pigs showing surra trypanosomes at the rate of 12 to 40 per field in their circulating blood and the infectivity of these ticks was later tested, in batches of 5 to 35, on healthy rabbits, at intervals ranging from 2 to 50 days, but none of the rabbits developed the infection during an observation period extending over about 25 days. These results would appear to be in accord with those recorded, at Liverpool, by Yorke and Macfie (1924), who, however, regard it as possible that their failure to reproduce the disease in this manner is attributable to the fact that, immediately after their infective feed, the ticks were

subjected to relatively low temperatures during their journey from India to England in the month of December. A proportion of the ticks used in these experiments were therefore kept in an incubator maintained at 25°C., but they proved to be no more infective than those kept at room temperature (20°C.).

The paper includes some observations on the bionomics of the young forms of *O. papillipes.*

## 18. On the nuclear structure of *Babesia bigemina* (Smith and Kilbourne).

H. N. RAY, Muktesar.

In 1930 Dennis from America described the structure of the nucleus of *Babesia bigemina* and since he noted the presence of blepharoplast in this organism he suggested its affinity with the Flagellata. According to him *Babesia* is of flagellate origin, and even if spirozoan, indicative of the polyphletic origin of that group.

In this article the author has described the result of his studies on the distribution of chromatin in the nucleus of the Indian strain of *B. bigemina.* The nuclear chromatin, as revealed by Feulgen's reaction, was found chiefly to be confined to the apical portion of the parasite, while a circular row of fine chromatin beads appeared to be connected with that main mass of chromatin. The nuclear structure presented varied appearances with different fixatives and stains. No evidence of a blepharoplast was however forthcoming.

## 19. Observations on the forms of *Babesia gibsoni* (Patton) in dogs.

H. N. RAY *and* J. A. IDNANI, Muktesar.

In view of our scanty knowledge about the morphology and significance of various forms of *B. gibsoni* in the verterbrate host, a detailed study was made, and the findings are recorded in this article.

Usually two types of the parasite, viz. ring forms and thin elongated forms, are met with in the smears made from the peripheral blood and in internal organs such as spleen, liver, and bone marrow. The ring forms were found to multiply by repeated binary fission until 12–16 merozoites were formed; while the thin elongated forms were observed to multiply in a manner which suggested a process of schizogony and gave rise to more than 30 merozoites in a corpuscle. Sometimes corpuscles infected with both the forms were seen in smears from the peripheral blood. This morphological differentiation into two forms is highly suggestive of sexual dimorphism in *B. gibsoni.*

## 20. On the occurrence of *Babesia bovis* Starcovici, 1893.

J. A. IDNANI, Muktesar.

Hæmoglobinuric fever in an Indian buffalo ascribable to what appears to be *Babesia bovis* Starcovici (1893) infection for the first time in this country is recorded. Blood smears from this animal were forwarded to this Institute from one of the Military Dairy farms with the history of acute piroplasmosis associated with hæmoglobinuria. Trypan blue had been administered without producing any effect.

On examination of the smears, the parasites were observed to be much smaller than those of tropical red-water, viz. *Babesia bigemina*; the angle at which the pointed ends of the double pears met was widely divergent and in some cases falling in a straight line. The characteristic marginal position of the parasites in the infected cells was also noticed.

The morphology of this organism as compared with that of *Babesia bovis* described by Wenyon (1926) presented no difference.

## 21. Bovine Theileriasis—preliminary report.

S. C. A. Datta, Muktesar.

Since the beginning of this century, *Theileria* parasites have been seen in the blood of Indian cattle and known as the 'small piroplasms' of Robert Koch, but researches upon this group of organisms may be said to date from 1925 and some advances have already been recorded. The morbid anatomy and histopathology of Theileriasis have not yet been studied in any great detail. The result of the studies so far carried out is described in this paper. The author has found that the predilection seat for the multiplication of the parasite is provided by the lymphoid tissue generally, including that in glands, spleen and other organs. Hæmorrhages resulting from parasitized endothelium of vessels have been seen in most organs. Large amount of cellular infiltrations in the Glisson's capsule of the liver and engorgement of capillaries with lymphocytes in particular have been constantly seen. Schizonts are more abundant in this organ than elsewhere. In addition to extravasated blood and blood pigments, the spleen shows enlargement of the malpighian bodies and the presence of parasites. In the kidneys, perivascular cellular infiltration, increase of the interstitium, and the very characteristic picture of minute superficial elevations with hæmorrhagic centres have been noteworthy. Parasites have been detected in almost all internal organs, including the brain. The morbid material under study has consisted of tissues collected from natural and experimental cases of acute Theileriasis.

Of the many therapeutic agents tried so far in the treatment of acute experimental cases, antisera from recovered cases have been found to give promising results. The second part of the article deals with the results obtained.

# Nutrition

## 22. Carotinoid feeding and goat's milk.

B. N. Banerjee *and* N. C. Datta, Bangalore.

The possibilities of feeding goats with tender leaves, carrots, and grasses have been studied. The physiology of the goat is different from the cow or buffalo, in that it either converts carotin into Vitamin A or rejects it. No carotin or xanthophyll can be detected in blood or milk fat even with excessive feeding. The nature of the carotin can be judged from the carotin content of the feed and fæces, and Vitamin A of the milk fat. Grasses are rich in beta carotin and leaves contain a high percentage of alpha and gamma carotin. The Vitamin A content of the milk fat can be increased with proper carotinoid feeding. The flow of milk as also the quality improves with carotinoid feeding.

## 23. The problem of Vitamin-A deficiency in the diet of farm animals.

K. C. Sen *and* P. A. Seshan, Izatnagar.

This paper attempts to summarize the present position of avitaminosis-A so far as it relates to the practical feeding of farm animals.

Cereals, grainfeeds, vegetable oils and oil-cakes are found to be poor sources of carotene (the precursor of Vitamin-A) which is generally associated with the pigments of all plant material.

Green young forage plants are, however, found to be satisfactory sources of carotene for animals.

The Vitamin-A requirements of rats, dogs, poultry, swine and cattle are discussed. The excretion, storage and depletion of the Vitamin-A reserve of animals through reproduction and milk are described.

The point is stressed that the provision of suitable green feeds or pasture land is the only practical method of supplying the carotene requirement of farm animals. In this connection, the importance of preserving the Vitamin-A potency of green plants when converted into hay or silage has also been emphasized.

The probability of the existence of avitaminosis-A, a mild form under the ordinary conditions of stock feeding in India, and the need of rectifying this condition are also considered.

## 24. Preliminary note on the behaviour of rice *kura* (bran) as a cattle food.

M. CARBERY *and* INDUBHUSAN CHATTERJEE, Tejgaon (Deccan).

The bran and rice polish form a large supply (probably about 32 million maunds) of cheap and easily available cattle food. The bran is very rich in oil, $P_2O_5$, and also MgO but very poor in lime. Preliminary experiments conducted with rice straw at Dacca Animal Nutrition Section show that the results were poor. The cause of it is suggested to be associated with maladjustment of minerals, existence of phosphorous as phytin and possible presence of decalcifying factors.

## 25. The value of *Aus* paddy straw as a fodder.

INDUBHUSAN CHATTERJEE *and* MD. ABDUL HYE, Tejgaon (Deccan).

The experiments conducted at the Animal Nutrition Section in Bengal show that *Aus* or Autumn rice straw is a much better roughage than *Aman* or Winter rice straw with respect to protein, lime and phosphorus. Data have been presented showing the behaviour in live weight, consumption, total digestible nutrients, etc. all pointing in favour of *Aus* straw.

## 26. Can Water Hyacinth be used as a cattle food ?

INDUBHUSAN CHATTERJEE *and* MD. ABDUL HYE, Tejgaon (Deccan).

As on account of fodder scarcity hyacinth is used as cattle feed in some parts of Bengal, its investigation was started to test its effect when given (1) with rice straw and (2) with rice straw and cake. It is noticed that in the former case the results were poor but better results were obtained with cake. The hyacinth is very rich in potassium and chlorine and also lime. The palatability appears to vary with locality, season and more or less with individual likes and dislikes. Under the fodder scarcity of the province its partial use is unavoidable but it is better to feed it in controlled amount and always supplemented with cake.

## 27. The lime and phosphorus requirements of Bengal cattle.

INDUBHUSAN CHATTERJEE *and* S. K. TALAPATRA, (Tejgaon Deccan).

Data from 24 individual tests have been presented suggesting the requirement of lime and phosphorus to be 48 grams CaO and 20 grams $P_2O_5$ per 1,000 lbs. live weight under the condition of rice straw feeding. The lime assimilation from rice straw is low and the requirement appears to be higher than under many other feeds. The phosphate deficiency is very large.

## Pathology and Bacteriology

### 28. An outbreak of Equine Encephalomyelitis in a mounted military police troop in Bihar. A preliminary report.

LAKSHMI SAHAI, Patna.

A description is given of an outbreak of Equine Encephalomyelitis in a mounted military police troop at Jamshedpur in Bihar, during which eleven horses were attacked, of which two recovered, two died and the rest were either destroyed or their destruction is contemplated.

The clinical features of the outbreak, the post-mortem findings and the histopathology of the lesions are described.

Chemical examination of the grass failed to reveal the presence of any poison.

Brain material from a case on sub-dural inoculation proved non-infective to rabbits but infective to guinea-pigs of which one died after showing paraplegic symptoms and another recovered after a febrile reaction.

A similar attempt in a horse using the intrathecal route failed.

The positive transmission results in guinea-pigs are interpreted to mean that the disease is probably of virus origin identical with the outbreak which occurred at Multan in 1933.

Finally, the relationship between Kumri and Equine Encephalomyelitis is discussed and stress laid on the epizootological and histopathological similarity existing between the two and the view is advanced that further research may perhaps show the two diseases to be due to a common etiological factor, such clinical differences as there may be between the two depending upon the differing elements in the central nervous system involved.

### 29. The incidence of *Salmonella enteritidis var. dublin* in pyosepticæmia of calves in India.

V. R. RAJAGOPALAN, Muktesar.

An organism isolated from cases of pyosepticæmia in calves, by Mr. Shirlaw at Lahore, has been typed as *Salmonella enteritidis var. dublin,* after a detailed study of its morphological, cultural and biochemical properties, as also of its antigenic constituents. Its antigenic structure has been found to be IX : gp : –., by a series of serological analysis. This is the first time that the incidence of this organism is recorded in India.

### 30. The incidence of *Corynebacterium equi* in a buffalo-cow.

V. R. RAJAGOPALAN *and* V. R. GOPALAKRISHNAN, Muktesar.

*C. equi* has been recognized by several workers as a cause of pneumonia in equines. It has not so far been recognized as occurring in any other species of animals. Its incidence in a buffalo-cow is therefore recorded in this article. Its identity with *C. equi* has been proved by morphological, cultural, biochemical, serological and biological tests. The significance of its incidence is discussed and it is held to be, at least, an etiological factor of post-abortion metritis, if not of abortion.

### 31. Neurolymphomatosis in poultry.

P. M. N. NAIDU, Hebbal (Bangalore).

The paper embodies the result of a preliminary study of this very interesting disease of poultry in Mysore.

The different manifestations of the disease in the fowl and its histopathological picture are described in detail.

Arguments are advanced on the strength of experimental evidence, incriminating some deficiency, most probably that of Vitamine C, as the possible etiological factor in this disease. It is possible that under certain conditions the tissues are unable to synthesize their requirement of this vitamine from its precursors, setting up metabolic disturbances of and inflammatory changes in the tissues involved resulting in a lymphocytic infiltration in them which is characteristic of the disease.

## 32. Diseases of the egg-laying apparatus of the hen.

P. M. N. NAIDU, Hebbal (Bangalore).

The most important organs of the domesticated hen, viz. the ovaries and oviduct, which are intended for the formation of the egg and its normal passage to the exterior, are subject to a variety of disease processes described in this paper.

The practical importance of a correct and early diagnosis of these conditions to commercial poultry farming is stressed upon.

## 33. Leg weakness in poultry.

P. M. N. NAIDU, Hebbal (Bangalore).

Leg weakness in poultry as a result of some constitutional disturbance in the fowl set up during the course of certain diseases is discussed under the following agencies causing them :—

1. Internal parasites.
2. Nutritional disturbances.
3. Infectious diseases.
4. Diseases of doubtful etiology, chief of which are—
   (*a*) Neurolymphomatosis,
   (*b*) Osteitis deformans,
   (*c*) Rheumatism,
   (*d*) Gout, etc.

## 34. Some common poultry ailments encountered in the Mysore State.

P. M. N. NAIDU, Hebbal (Bangalore).

Experience gathered during a period of about two years' study of the most common diseases fatal to poultry in the State, with special reference to their occurrence, etiology, symptoms and differential diagnosis is described in this paper.

## 35. A controlled epidemic in Guinea-pig colony.

K. D. MANOHAR, Bombay.

While supervising the animal house the writer had an opportunity of studying the ecology of an epidemic in guinea-pigs. The epidemic, though natural as far as importation of the virulent organism was concerned, occurred in a controlled colony, in which, as a control measure, isolation of the healthy and susceptibles was immediately carried out, and also the destruction of the obviously sick animals.

The epidemic therefore resembles a human epidemic more or less modified by the active interference of health authorities.

Weather considerations were important. After a very hot spell rains set in violently. The animal house leaked badly and the animals were soaked through. Feeding was naturally unsatisfactory, the food getting sodden and dust-laden within a few hours of distribution The rapid decomposition of food must also have diminished the available food

considerably. Flies had come in swarms. Such was the condition of animals when the epidemic broke out. The first impression was that the food was the source of infection. But food was ruled out as a possible factor by the observation that isolated animals in cages completely escaped the epidemic, although fed on the same food stock. In addition to being isolated in cages, these animals were housed in well-protected rooms. Secondly, on post-mortem examination of animals, the intestines did not show inflammatory change while the lungs were definitely hæmorrhagic and showed broncho-pneumonia patches.

Discussing the subject with Dr. Gharpure, of Grant Medical College, he pointed out that Broncho-Pneumonia was often the cause of death in groups of guinea-pigs.

The attending *hamal* also informed that every rainy season, an epidemic did occur and killed off almost half the animals.

## 36. A preliminary report on the viability of *Mycobacterium paratuberculosis enteritis* under conditions simulating those in the field.

P. C. Banerji *and* K. Raghavachari, Muktesar.

A perusal of the available literature on Johne's disease shows that there is no authentic information on record concerning the viability in nature of the specific bacilli of the disease. As the elucidation of this point is obviously essential for the purpose of applying measures of control on a rational basis, a series of viability tests were carried out upon *Mycobacterium paratuberculosis enteritis* which were found in the fæces of a cow affected with Johne's disease four years after the fæces had been maintained under conditions simulating those obtaining in the field. Most of the organisms have undergone considerable morphological changes, but multiplied readily and regained their normal form when cultured in suitable media.

## 37. Cysteine hydrochloride as a suitable reducing agent in glucose broth for obtaining cultures of *Clostridium chauvoei* for the routine production of blackquarter vaccine.

V. R. Rajagopalan, Muktesar.

The prophylaxis of blackquarter with the aid of spore cultures in the form of dried and heated muscle pulp, and with the natural and artificial aggression has given place, in recent years, to vaccination with formalized cultures.

For obtaining massive growths for the purpose, glucose broth containing pieces of autoclaved meat, pieces of sterile tissue or the heart of inoculated guinea-pig was first being used. This had the disadvantage that débris from tissue used for creating anærobiasis became mixed with the bacterial emulsion. Mc. Even (1926) introduced a device by which bacterial emulsion could be obtained free of all tissue débris. He used a diffusion shell to contain the minced pieces of liver. Sheather (1928) replaced the diffusion shell with a porcelain cell.

This article records the results of a preliminary investigation into the possibility of substituting cysteine hydrochloride for tissues for the creation of anærobiasis. A freshly made solution of cysteine hydrochloride was added to glucose broth to give the required concentration. As small a concentration as 0·01% was sufficient to produce anærobiasis, provided a layer of paraffin was superposed. If a higher concentration was used (0·05 to 0·1%), the paraffin layer could be dispensed with.

A test was made of the prophylactic value of the formalized vaccine made from cysteine hydrochloride broth cultures that had been grown for two days and fourteen days, as well as of filtrates made from them. All the eight bulls and six guinea-pigs vaccinated with the vaccine withstood a retest with a lethal dose of *Cl. chauvoei* culture. Seven of the eight bulls and five of the six guinea-pigs treated with the filtrates withstood a retest inoculation. All the control bulls and guinea-pigs (two of each) died of typical blackquarter. In a second test, the cysteine hydrochloride broth vaccine was found not to be inferior to vaccines made from media containing tissues.

It was found incidentally that a strain of *Cl. chauvoei*, which had been in subculture for a long time, was capable of growing in simple glucose broth, without further anærobiasis. It was non-virulent for bulls, but a preliminary test showed that it retained its immunizing properties.

## 38. Studies on a natural outbreak of pigeon pox.

R. L. Kaura *and* S. Ganapathy Iyer, Muktesar.

A natural outbreak of pigeon pox occurred in a stock of healthy pigeons at this Institute and the source of infection was not traceable. The causative agent was demonstrated to be a filtrable virus and has been maintained by passage through pigeons. This appears to be the first recorded outbreak in India.

Immunological tests of the virus isolated indicate certain degree of antigenic variations from the English strain of pigeon pox virus obtained for comparison, although both are similar on grounds of pathogenicity and their capability to protect fowls against fowl pox.

Preliminary complement fixation tests showed that complement fixing bodies were rarely demonstrable in the sera of healthy as well as pigeon pox immune birds.

## 39. Actinomycosis and actinobacillosis in animals in India.

M. Y. Mangrulkar, Muktesar.

Examination of recent specimens received at the Imperial Veterinary Research Institute indicated the prevalence, although apparently rare, in India of conditions which show lesions histopathologically indistinguishable from, or closely simulating, those of Actinomycosis and Actinobacillosis. This led to a thorough microscopical re-examination of all specimens from March 1922 to August 1937 and to the preparation of the present paper with the object of recording lesions wherein 'actino' bodies have been produced due either to a Gram positive mycelium or to Gram negative micro-organisms. Although no facilities for cultural examination were forthcoming nor was a complete clinical history available in every case, it seems certain that in India both types of infection occur. A case of canine actinomycosis is included. It is hoped that the attention of veterinarians in India will be drawn towards these conditions and that the desired scientific data will be made available in future.

## 40. Melanomata in domesticated animals.

M. Y. Mangrulkar, Muktesar.

The paper is a histopathological study of the melanomata in the collection of the Imperial Veterinary Research Institute and includes a detailed clinical record of an equine case. Comparison is made between animal and human melanotic tumours, and the nomenclature is discussed.

## Serology

### 41. Preparation of dried anti-rinderpest serum by alcoholic precipitation and desiccation *in vacuo*.

R. L. KAURA, Muktesar.

The active fractions of anti-rinderpest serum, special and ordinary, consisting of antibodies and the serum proteins, precipitated by 30 per cent. alcohol at 0°C. and desiccated after filtration, over phosphoric anhydride *in vacuo*, have been found to be practically equal in weight per volume of serum. When subsequently redissolved in normal saline solution to the original volume, the precipitate suspension, entirely soluble, was found to produce a protective effect on hill bulls equal to that of the original serum, thus indicating that the entire active principles of the serum had been precipitated. Moreover, it was determined that the immunizing value of the dissolved precipitate depended directly upon the rate of dilution.

### 42. Changes in phosphorus and calcium content of blood during rinderpest syndrome in hill bulls.

R. L. KAURA, Muktesar.

Daily variations in the phosphorus and calcium fractions of the blood during rinderpest syndrome in hill bulls, from the day of inoculation to death, or in the case of recovery for fourteen days after the inoculation, have been made. The normals for each animal under experiment were previously obtained.

It has been found that, during the rinderpest syndrome in hill bulls, there is a fall in the blood phosphorus which corresponds with the degree of reaction and a subsequent rise on the subsidence of reaction. There appeared a tendency for the blood phosphorus to rise sharply prior to death. The calcium level remained practically unaffected throughout.

Intravenous injection of sodium phosphate into hill bulls 48 and 72 hours after inoculation with rinderpest virus, resulted, within 15 minutes, in the increase of blood phosphorus lasting for about an hour followed, in about 6 hours, by a marked decrease and again coming up to the normal level by the 48th hour, without upsetting the blood calcium to any marked extent. It had no curative effect on the infected animals.

## Helminthology

### 43. Helminthology in relation to Veterinary Science.

H. D. SRIVASTAVA, Muktesar.

The importance of helminthology in the conservation of public and animal health is often not fully realized, as the common symptoms of helminthiasis—a prolonged and progressive afebrile unthriftiness gradually resulting in death—are not always sufficiently spectacular to attract immediate attention. In this paper the author points out that in a tropical country like India, and one in which animal hygiene is little developed, helminthiasis is a most serious menace to the health of stock animals. The losses due to some of the important helminths are discussed and the urgent need of intensive research on the subject is indicated.

### 44. Helminth parasites of dogs—their treatment and control.

H. D. SRIVASTAVA, Muktesar.

The paper includes an account of the life-histories of the common helminth parasites of dogs. The pathogenicity, treatment and control

of parasites are discussed. The importance of parasites of the dog in relation to public and animal health is pointed out.

### 45. Verminous pneumonia in domestic animals—its control and treatment.

H. D. SRIVASTAVA, Muktesar.

Verminous pneumonia is responsible for very high mortality amongst the domestic animals, specially sheep and goats, in several parts of the country. In spite of the high incidence of the disease no sure method of its treatment or prevention is known. In this paper the author discusses the life-histories, treatment and control of the important lungworms of domestic animals. The importance of proper feeding in fighting the infestation with lungworms is also discussed.

### 46. On a new species of *Psilorchis* Thapar and Lal, 1935, from the intestine of the common teal, *Nettion crecca*.

M. B. LAL, Lucknow.

Thapar and Lal (1935) described the genus *Psilorchis* from the intestine of a king-fisher. During the course of our investigations on the trematodes of birds, a few specimens were obtained from the intestine of a common teal at Ajgain. The present form differs from the existing species in the following features :—

1. Highly developed funicular testes.
2. Coalescence of the vesicula seminalis with the ventral sucker.
3. Extremely small pre-pharynx.
4. Shape of Ovary.
5. Nature of Vitellaria.

Full details of the anatomy of the trematode are given in the paper.

### 47. On a new trematode of the family Echinostomidæ from the spotted red-shank.

M. B. LAL, Lucknow.

Two mature specimens of trematodes were collected during the post-mortem examination of a number of spotted red-shanks at Lucknow. The trematodes which belong to the family Echinostomidæ present the following interesting features : cirrus sac dextral and not contiguous with ventral sucker, testes are not contiguous, uterus is much convoluted, and receptaculum seminis uterinum absent.

Full details of the anatomy and the systematic position of the form are discussed in the paper.

## Pharmacology and Therapeutics

### 48. Effect of trypan-blue on goat blood virus.

P. G MALKANI, Patna.

Experiments carried out to determine how addition of trypan-blue to rinderpest goat blood virus affects its viability have shown that—

1. After addition of 1% solution of trypan-blue in 5% concentration, the virus, preserved (i) at cold storage temperature (36–40°F), is viable on the 14th but dead on the 21st day ; (ii) at summer temperature (75–85°F), is viable on 2nd but dead on the 7th day ; (iii) at winter temperature (60–75°F), is potent up to 11 days.

2. After addition of 1% solution of trypan blue in 50% concentration, the virus, preserved (i) at cold storage temperature, is potent on the 7th but dead on the 14th day; (ii) at summer temperature (75–85°), is potent on 2nd but dead on the 7th day; (iii) at winter temperature (60–75°), may be potent even on the 11th day.

In view of these and author's previous findings that pure blood virus at cold storage temperature remains potent for as long as 22 days, it is concluded that the addition of trypan-blue shortens the period and that this 'shortening' appears to be directly proportional to the concentration of trypan-blue. The 5% concentration, however, leaves the viability unaffected for a sufficiently long time. If it gives similar results with bull virus it can be used for purifying it of Protozoan parasites in vitro and masking the colour of blood, so repugnant to the religious sentiments of the ryots.

## Entomology

### 49. Observations on the bionomics of the ox warble-fly (*Hypoderma lineatum*).

B. N. Soni, Muktesar

Observations carried out by the author since January, 1937, at the Imperial Veterinary Research Institute, Muktesar, have shown that over 50% of the hill bulls purchased for experimental purposes are infested with warble grubs (*Hypoderma lineatum*), and that it takes nearly 52 days for the larvæ to mature after their first appearance in the subcutaneous tissues of the animal's back. In two instances, the adult flies were successfully reared from larvæ that had been entrapped while in the act of escaping from the warble tumours. Evidence has also been obtained that the presence of these tumours results in a loss of condition of the affected animal.

In the writer's experience at Muktesar the occurrence of the oesophageal forms of *H. lineatum* was noticed first towards the end of March, 1937, and thenceforward they were encountered continuously during the observation period of about 5 months. The significance of the occurrence over such a long period is not understood and it would appear difficult to reconcile this finding with the generally accepted view that there is only one annual brood of *H. lineatum* in India.

The presence of warble tumours in dairy cows and of oesophageal larvæ in bulls born and bred at Muktesar shows that the pest is indigenous to this locality.

The results of a short survey carried out in the Punjab have revealed the fact that in certain localities in that province the larvæ reach their final stage in the back by the end of September and no tumours in the back are noticed after the middle of January, while at Muktesar the larvæ in the back have been encountered as late as the beginning of March.

## Immunology

### 50. Heredity and disease resistance.

F. A. E. Crew, Edinburgh.

The problem of resistance to disease is of great scientific interest and also of vital practical and economic importance. It is a complex problem demanding for its attempted solution the aid of the bacteriologist, the protozoologist, the physiologist and the geneticist together with others.

The degree of resistance, ranging from immunity to extreme susceptibility, depends upon a multiplicity of factors which may be grouped under the headings: environment, function and inheritance.

The evidence in favour of inherited predisposition to or relative immunity from disease is overwhelming, but the relative importance of heredity, function and environment still remains an unsolved problem.

### 51. Is lifelong immunity against rinderpest conferable on bovines ?

P. C. BANERJI, Muktesar.

Two cows and a bull born of immune dams and reared at the Dairy of the Imperial Veterinary Research Institute, Muktesar, were immunised against rinderpest by the serum-simultaneous method using bull virus, at ages between 3½ months and 15 months. They were administered a second dose of the virus 7 to 9 days later and a third dose of 5·0 c.c. at periods ranging from 7½ months to 33 months after the initial inoculation. When tested for immunity by the subcutaneous inoculation of 5·0 c.c bull virus 6½ to 14½ years after their primary immunisations, all the three animals proved to be solidly resistant to the infection as was evidenced by the 'blocked out' reaction obtained in each case.

From the above experiment it may be concluded that animals immunised by the serum-simultaneous method followed by a dose of bull virus in reinforcement are liable to develop a lifelong immunity against rinderpest.

## Biochemistry

### 52. Blood protein fractions in the normal, and vitamin A, calcium and phosphorus deficient bovines and equines.

N. D. KEHAR, Muktesar.

A detailed study of the various changes in the protein fractions, consisting of total protein, non-protein nitrogen, albumin, total globulin, pseudoglobulin I, pseudoglobulin II, and euglobulin has been made in the blood of normal as well as of vitamin A, calcium and phosphorus deficient equines and bovines. Observations recorded so far, show that the antibody forming fractions of globulin are considerably less in the deficiency animals compared to the normal.

### 53. Vitamin A losses in hay and fodder conservation.

N. D. KEHAR, Muktesar.

One of the most important problems in animal husbandry is the application of the best possible practice in conserving hay and fodder plants. Attempts have been made to find out the effect of different methods of conservation practised in India on the vitamin A content of grasses and other fodder plants. It has been observed that sun drying exerts a considerable influence on their vitamin A content.

### 54. Biochemical and physico-chemical factors in the etiology of bovine hæmaturia.

N. D. KEHAR, Muktesar.

The different views about the etiology of hæmaturia are, as yet, not universally accepted. An investigation has thus been initiated into the biochemical and physico-chemical characters of blood and urine of hæmaturia cows as a possible aid to help elucidating the evidence already available.

## 55. The rôle of mineral deficiency in equine abortions.

V. R. RAJAGOPALAN, Muktesar.

It is known that mineral deficiency may lead to abortion in certain farm animals. These abortions occur through starvation of the fœtus of essential minerals, through metabolic changes induced by disturbances of the endocrine system or through predisposition to infections.

The writer had an opportunity to investigate the cause of an outbreak of equine abortion. The possibility of infection with micro-organisms and intoxication with foodstuff was eliminated after a thorough examination. The analysis of blood serum revealed hypocalcæmia. The blood calcium ranged from 7·7 to 9·0 m.gm. per 100 c.c., as compared with an average of 12·3 m.gm. per 100 c.c in normal mares. This suggests that calcium deficiency was the cause of these abortions. This is corroborated by the following observations: This stud consisting of about forty brood mares used to suffer five to seven abortions per year before 1929. A mineral supplement came into use from 1929. Abortions disappeared from the farm simultaneously. The mineral supplement was discontinued in 1934. Two abortions occurred in 1935 and thirteen in 1936 up to the month of May. Hypocalcæmia was now detected, and a mineral supplement was reintroduced. The incidence of abortion has since practically ceased.

## 56. Investigations into the effect of mineral deficiencies on the resistance of ruminants to helminthic infestations, and the most practical method of combating the parasites.

U. W. F. WALKER, Lahore.

In this paper are incorporated the results of experiments carried out on the treatment of gastro-intestinal round-worms in ruminants. A number of drugs was tried, out of which a combination of copper sulphate and Kamala was found to be the most efficacious and cheap.

As a result of a series of controlled experiments it has been concluded that fodders deficient in minerals tend to lower considerably the resistance of ruminants to helminthic infestations.

Certain abnormal changes have been observed in the animals kept on unbalanced rations.

# SECTION OF PHYSIOLOGY

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Honorary Physician to the King.

## General Physiology

### 1. Normal gastric acidity in Indians.

L. Everard Napier, Calcutta.

Until recently it has been stated from time to time that the acid secretion in Indians living in India is lower than in Europeans, both in those living in hot climates and in temperate zones. In this paper, an attempt has been made to test the validity of this statement.

During the last year, a series of gastric analyses with alcohol test meal were done in the Tropical Diseases Hospital.

The general conclusion is that there is no lowering in the acidity level in Indians in India, and that, though a hot climate and a vegetarian diet are both said to be factors that tend to diminish gastric acidity, in actual fact this does not occur. On the other hand, there is some evidence that gastric acidity is actually increased.

### 2. On the composition of sweat of the Indians.

R. N. Chopra *and* A. C. Roy, Calcutta.

Analyses of a number of samples of sweat (free perspiration) collected from several normal individuals living in and around Calcutta were made with respect to some of the more important constituents. Widely varying results are reported by different workers. If the data presented by McSwiney be accepted as more or less representative of that obtained in temperate climates, our results show somewhat different values. The reaction of the sweat was invariably found to be acid, the pH varying from 4·6–5·7 (average 4·94); McSwiney reported a variation of pH 5·1 to pH 7·35 (average pH 61·14). The chloride content varied from 0·073 to 0·844% (average 0·44%) as against 0·37% (McSwiney). Ammonia-N varied from 7·5 to 34·2 mg. per 100 c.c. (average 19·3 mg.%) against 4·7 mg.% (McSwiney). The variation in urea N was between 10·4 to 61·5 mg.% (average 30·6 mg.%) against 20·44 mg.% (McSwiney). Only traces of phosphate could be detected. The majority of the specimens did not reduce ' indophenol ' to any appreciable extent.

### 3. Effect of temperature variation on brain impulses.

R. N. Chopra *and* N. N. Das, Calcutta.

The effect of changes in the temperature on the nature and character of impulses coming from the cerebral cortex was studied in anæsthetised animals with the help of an oscillograph and silver silver chloride electrodes. The changes were most marked in the action potential and

in the frequency. Lowering of temperature lowers the potential of the impulses but makes them steady and uniform. Frequency is also lowered but is maintained uniform throughout. At higher temperatures, however, the action potentials of impulses are as a rule higher but they are never steady ; on the contrary they show fluctuations in amplitude and therefore in potential. The frequency also increases in such cases but they tend to lose their uniformity as the temperature is raised higher and higher.

## 4. Pigment studies in Indian and European skin.

L. M. GHOSH *and* D. PANJA, Calcutta.

Inhabitants of the tropics usually possess a darker skin than those resident in the sub-tropical and temperate zones. This is due to the presence of a pigment, melanin in the skin. As the presence of pigment in the skin is thought to play a part in tropical adaptation, an investigation was undertaken to see whether there is any quantitative or qualitative difference in the pigment present in the European and the Indian skin. A comparison of stained skin sections of the two races shows that the Indian skin has a greater concentration of melanin in the basal cell layer. The differences in the chemical composition of the pigment and the influence of other external conditions on the mechanism of pigment concentration are discussed.

## 5. Observations on the basal metabolism of healthy subjects under varying conditions of temperature and humidity.

BASHIR AHMAD, R. B. LAL, *and* N. C. RAY, Calcutta.

The American standards of basal metabolism though applicable in Europe and America require modification when applied to other regions. The reports of basal metabolism from Asiatic countries suggest a lower standard. The influence of climatic conditions on basal metabolism has also been studied and found to be lower in the tropics. However the exact rôle of racial and other factors, apart from the climatic influence, on the variation in metabolism still remains unsettled.

The present report is based on studies in basal metabolism of 9 young healthy Indians under two different sets of atmospheric conditions with regard to temperature and humidity, viz. the outside atmosphere during monsoon in Calcutta and the air-conditioned rooms in the Hygiene Institute, existing side by side so that the effect of sudden changes could be observed on the same subjects.

Our results show (i) the basal metabolism of each subject in outside atmosphere is lower than that of the American standards. (ii) The basal metabolism of all the subjects on going to the air-conditioned rooms from outside is still lower.

The data though meagre seem to suggest that individuals vary in their response to the atmospheric conditions.

## 6. The seasonal variation in basal metabolism.

S. A. RAHMAN, Hyderabad (Deccan).

Basal metabolism tests were made on 31 days on a single subject from September, 1936 to July, 1937. The results were strikingly uniform, most of the results being within 2 per cent. of the average. The average for the 31 days worked out as 12·1 per cent. below Harris-Benedict and 18·3 per cent. below Aub-DuBois standards.

There was no marked difference in the results obtained during the winter and the summer months. In fact, contrary to expectation, the results obtained during the summer months (May and June) were slightly

(2·5 per cent.) higher than those obtained during the winter months (November and December).

There was a slight but definite lowering of basal metabolism in the months of July as compared with the results obtained in May and June. The cause for this is discussed.

## 7. A note on the basal metabolic rate in Indians.

S. L. BHATIA, Bombay.

The Basal Metabolic Rate of a large number of Indians of different communities have been determined. The results obtained have been discussed.

## 8. Urinary composition of normal Bengali subjects.

S. N. ROY, Calcutta.

The average composition of the urine of middle-class Bengalees of normal health is given. The averages are based on the analyses of a large number of normal urines each collected over a period of twenty-four hours. It is found that total nitrogen, urea, inorganic sulphate, and calcium excretions are greatly lower, chloride excretion is definitely higher, and creatinine, uric acid, ethereal and neutral sulphate and inorganic phosphate outputs are more or less the same as compared with the corresponding figures for normal European or American subjects on ordinary mixed diets. The significance of these findings are discussed.

## 9. The electrical charge of carbon particles and their phagocytosis by polymorphonuclear leucocytes.

S. N. MUKHERJEE, Calcutta.

Attempts have been made to correlate the electrical charges on carbon particles suspended in different concentration of sodium chloride with their percentage phagocytosis under corresponding conditions, keeping the osmotic pressure of the suspending media constant and equal to that of normal saline by the introduction of calculated amounts of glucose and M/15 phosphate buffer of pH 7·3.

Surface charge of negative particles has been observed to diminish with increasing concentration of sodium chloride in medium and a slight reversal of charge at higher concentrations were also observed. The percentage of phagocytosis increased with the diminution of negative charge and reached a maximum value near about the neutral point of the carbon particles which was observed at a concentration slightly lower than 0·85% sodium chloride solution.

## 10. The elasticity of the lung.

B. B. SARKAR, Calcutta.

In a previous work, the author while attempting to demonstrate the pressure variations in the alveoli found that the elastic recoil of the lung, as determined by the differences of pressure between the inside and outside of the lung, does not increase, as is supposed, with the distension of lung. The present work was undertaken to determine the elastic recoil of the lung under different conditions of distension.

The negative pressure, (in the air-tight chamber encasing the animal), which is keeping the lung inflated when the intrapulmonary pressure is kept normal, being the elastic recoil, was recorded. When the pressure outside the lung wall (in the chamber) in an inflated lung is made equal to the atmospheric pressure, the distended lung wall raises the intrapulmonary pressure by an amount equal to its elastic recoil, which was also recorded.

In every case the results of the experiments on the lung were compared with the results obtained by using a thin-walled rubber balloon and a thick-walled football bladder in the same way.

From the results of these experiments it has been found in every case that, like other substances having elastic properties, these elastic membranes show an increasing elastic recoil when just getting distended, but soon reach a limit beyond which further recoil is not possible. In the rabbit the elastic recoil in the inflated lung was found to be about 50 to 55 mm. of water.

## 11. The part played by the elasticity of the lung in respiration.

B. B. Sarkar, Calcutta.

In the previous paper it has been demonstrated that the elastic recoil in the distended lung remains unaltered. In the present paper an attempt has been made to find out the part played by this property of the lung-wall in normal respiration.

In normal respiration the lung-wall is kept in close contact with the thorax wall, by a negative pressure in the intrapleural space which is equal to elastic recoil of the lung. The natural tendency of the lung to collapse is thus just prevented by this amount of negative pressure, resulting in the lung-wall behaving as an inert membrane, being, as it were, balanced by two equal and opposite pressures. Consequently any pressure differences which are created inside the lung (alveoli) as the result of inspiratory and expiratory movements are readily transmitted to the intrapleural space. It has been found that when the intrapleural pressure is reduced beyond the elastic recoil value of the lung, causing an active pull on the lung-wall, the respiratory variations of the intrapleural pressure cease altogether. They start again when the elastic recoil of the lung is again balanced, as by increasing the intrapleural pressure to its former (elastic recoil) value or by proportionate reduction of the intrapulmonary pressure.

Experimental lowering or raising of the intrapulmonary pressure correspondingly lowers or raises the intrapleural pressure.

## 12. On the osmotic relationship between egg-white and egg-yolk and the effects of injection of potassium cyanide and sodium fluoride on it.

N. M. Basu *and* M. C. Mitra, Calcutta.

These experiments were undertaken to find out if the difference in osmotic pressure between egg-white and yolk as observed previously by Straub and by Hill is due to Donnan membrane equilibrium or the vitality of the vitellin membrane separating yolk from white. If the difference be due to Donnan membrane equilibrium, injection of substances like KCN or NaF will not disturb this equilibrium ; if due to vital activity of the membrane, the reverse result will take place. It was found that after the injection of both KCN and NaF in suitable concentrations, the difference in osmotic-pressure gradually diminished, although there was no change in osmotic-pressure in the control eggs in the same period. The marked diminution in the difference of osmotic-pressure cannot be wholly explained by the addition of osmotically active substances caused by the injection of KCN and NaF.

## 13. Experiments with choline.

W. Burridge *and* D. N. Seth, Lucknow.

The action of choline in dilutions varying from one part in $10^{-2}$ to one part in $10^{-14}$ has been studied on the perfused frog's heart. The drug

is added to a perfusing solution containing too little calcium to maintain cardiac activity for more than half an hour and the effect of the drug is observed by noting its power to depress or stimulate the activity of such a preparation. Choline acts as a cardiac depressant between dilutions $10^{-2}$ to $10^{-8}$. No action is elicited when a dilution of $10^{-9}$ is used. The cholinised heart not only recovers completely from the depressant effects after washing but also shows an indefinite prolongation of activity. This maintenance-capacity of choline has been assumed to be due to its entering into some firm chemical combination with some constituent of heart muscle. Certain theoretical implications of the depressant action of choline on nerve-cells are also discussed.

### 14. Variation in the absorption of drugs from the gastro-intestinal tract.

B. SEN, Calcutta.

Drugs possessing reputed therapeutic properties have not infrequently been found to show variations in their effectiveness. The efficacy of a drug is mainly dependent on the normal physiological process of absorption but this is very likely to be disturbed to a considerable extent by any abnormality in the secretions of the gastro-intestinal tract, the intestinal flora, the peristalic movements, the conditions of the gall-bladder and the appendix.

## Hæmatology

### 15. The normal blood picture in Indians.

L. EVERARD NAPIER, Calcutta.

The normal blood picture of Indians in Calcutta has been studied and compared with the normal blood picture of the people of temperate and cold climates. It has been shown that there is no gross difference in the hæmoglobin or cellular content of the blood in Europe and India; if anything, contrary to previous teaching, the hæmoglobin is higher in India. With the possible exception of the higher eosinophilic count, the differences that have been observed have no pathological explanation.

The blood picture of the so-called normal coolies in tea-garden labour forces is also investigated. It has been shown that the mean hæmoglobin is much lower than that of the city-dwelling Indians though the number of red cells is about the same. It is pointed out that this low level of hæmoglobin cannot be considered to be due to climatic or racial factors but is probably associated with diet and subclinical infection, e.g., hook-worm infection.

### 16. Hæmoglobin in relation to food requirements.

G. SANKARAN, Coonoor.

It is usual in nutrition to relate food requirements and body-weight. From a physiological point of view, this may be irrational. Two individuals, one thin and the other fat, may have similar amounts of metabolising tissue, and their total energy requirements may be similar though requirements per kilo. are different. There is still another factor to be considered—the capacity of tissue to utilize nutritive elements. Leaving pathological conditions out of consideration, the capacity of tissues in this respect must be dependent on the oxygen present, and hence will be influenced by the amount of oxygen carried—i.e., hæmoglobin—in the body.

The amount of oxygen required for 'burning' different foods and the amount of hæmoglobin in circulation needed to carry this amount of oxygen, are considered. Data are presented showing that, in a series of

individuals, there was no relation between weight and the hæmoglobin content of the blood.

It is concluded that the latter should be taken into account in considering food requirements. Ill-nourished individuals are usually anæmic. It may be necessary to correct their anæmia before they can fully utilize a richer diet.

## 17. Mean red-cell diameter of South Indians.

G. SANKARAN *and* M. V. RADHAKRISHNA RAO, Coonoor.

A study of the mean red-cell diameter of South Indians was undertaken by a modified area method with a view to establishing normal standards. The method is simple and less time-consuming than the original Price-Jones' method. Data are presented of 25 cases, including both males and females. A statistical analysis of the data showed for South Indians a mean red-cell diameter of 6·85 microns, with a standard deviation of 0·28 microns, and coefficient of variation of 4·1 per cent. These figures show that the mean red-cell diameter of South Indians is somewhat smaller than that given by Price-Jones (7·202 microns) for Europeans.

## 18. The Arneth count in tropics.

DHARMENDRA, Calcutta

The results of the Arneth counts of fifty apparently healthy Indians are reported. The counts show a left-handed shift as compared to the standard in Britain. The counts are shifted to the left nearly to the same extent as in the case of Iraquis and Chinese. They do not show as much left-handed shift as do the counts of Alonites in North Syria.

The shift does not appeár to be due to any active or latent infections of a minor degree in apparently healthy individuals or to any racial or dietetic factor. It appears to be dependent on some environmental factor or factors which are common to the tropical and subtropical countries. Not much is known about the nature of these factors or about the way in which they bring out this left-handed shift.

## 19. A hæmoglobin constant.

S. S. SOKHEY *and* MALANDKAR, Bombay.

For a hæmatologic study of 121 normal men and 101 normal women of the Bombay Province, between the ages of 18 and 30 years, all the hæmoglobin estimations were made with the Van Slyke's Oxygen capacity method. An average of 15·37g. of hæmoglobin per 100 c.c. of blood for men and an average of 12·99g. for women were obtained. These averages tallied exactly with hæmoglobin averages for men and women worked out in United States of America by the same method, (Men—Haden, 15·37g.; Dill, 15·36g.; Women—Haden 12·93g.), in spite of the fact that dietetic habits and the climatic conditions under which the Indian and American subjects lived were so dissimilar. This observation raised the question of a possible hæmoglobin constant. A study has been made and results are presented.

## 20. 'Spring' of hæmoglobin.

S. N. MATHUR, Lucknow.

As a result of experiments done on healthy medical students, it has been found out that the percentage of hæmoglobin shoots up in the spring months. Man in this respect appears to be in sympathy with the rest of the nature.

### 21. Hæmoglobin level of Indians at an altitude of 6,000 feet above mean sea-level.

G. SANKARAN *and* K. RAJGOPAL, Coonoor.

A study on the hæmoglobin content of the blood of 20 male Indians in Coonoor (at a height of 6,000 feet above sea-level) has been carried out, using the Van Slyke apparatus for determining the oxygen capacity of blood. The average figure of hæmoglobin was 16·45 grms. per 100 c.c. Don and Jenkins give the average of 118 English males as 15·85 grms. per 100 c.c. Price-Jones, Vaughan and Goddard give 14·71 grms. hæmoglobin as the average for 100 English adults. Napier found an average of 14·77 grms. hæmoglobin in 50 Bengalees. The altitude factor is probably responsible for the relatively high hæmoglobin content in Indian at Coonoor.

### 22. The normal polynuclear (Arneth) count at Hyderabad (Deccan).

S. A. RAHMAN *and* M. A. ZAIDY, Hyderabad (Deccan).

Eighty-eight healthy men at Hyderabad (Deccan), from 15 to 45 years of age, were examined for the total white cell count and the polynuclear (Arneth) count The total count varied from 4,000 to 13,100, the average being 7,128. The average weighted mean of the polynuclear count was found to be 2,442. This figure is slightly lower than that obtained by Kennedy in Scotland, and still lower than the figures obtained by Cooke and Ponder. The probable causes for the low results at Hyderabad have been discussed.

### 23. Diurnal variation in the white cell count in the tropics.

C. R. DAS GUPTA, Calcutta.

It has been shown by workers in Europe and America that there is a great diurnal variation in the white cell count in the normal healthy individuals at rest and that this variation is independent of the digestive processes. These observations have been confirmed by the writer in a series of healthy volunteers whose blood counts were recorded every hour during the day. The count usually reached a maximum in the afternoon.

In eight habitual foot-ball players whose blood was examined before and after a game of strenuous foot-ball in the summer, no marked leucocytosis was seen in any case after the game. The diurnal variation in the leucocytes as also the leucocytosis observed under various physical and psychical conditions, e.g. exercise, fear, etc., is due to re-distribution of cells from stagnated viscera to the periphery and as such, is not accompanied by any departure from the normal leucocytic formula in the Arneth count.

## Pharmacology

### 24. Hæmolytic action of some hydrocupreidine derivatives.

R. N. CHOPRA, B. MUKERJI, *and* M. CHAKRAVARTY, Calcutta.

The alkyl ethers of hydrocupreidine have all been synthesized by Ghosh and Chatterjee (*Jour. Ind. Chem. Soc.*, 8, 257 ; 9, 83). A comparative study of the hemolytic potency of these compounds with their corresponding levo-rotatory isomers and quinine has been made in this paper.

Red blood corpuscles of rabbits and human beings were made plasma-free by repeated washings and centrifugalization and suspended in physio-

logical saline. To this, equal volumes of different concentrations of Hydrocupreidine and Hydrocupreine salts were added, taking special care to see that the $p$H of the solutions were maintained within the constant range of 5·6 to 6·3. Two series of observations were made: (1) The minimum time for starting of hemolysis, keeping the concentration of the different salts constant, and (2) the minimum concentration just necessary to produce hemolysis, by keeping the time of exposure of the corpuscles to the different dilutions constant. The quantitative hemolytic potency of the different compounds in terms of quinine has been calculated from this latter observation. It was found that the dextro-rotatory hydrocupreidine derivatives were stronger hemolytic agents than quinine, the hemolytic potency increasing steadily as the higher homologues were reached ($n$-Octyl Hydrocupreidine about 100 times stronger than Quinine Hydrochloride). The addition of serum diminishes the hemolytic potency to a very large extent. The levo-rotatory hydrocupreines are almost identical in action to the dextro-rotatory isomers, as far as the hemolytic activity is concerned.

## 25. Comparative action of hydrocupreines and hydrocupreidines on digestive enzymes. Part I. Carbohydrate digestion.

B. MUKERJI *and* N. K. IYENGAR, Calcutta.

The comparative inhibitory action of a series of dextro-rotatory hydrocupreidine derivatives and their corresponding levo-rotatory isomers on salivary and pancreatic amylase and on yeast invertase was studied. Quinine has been taken as the standard for comparison.

The method of Willstatter, Waldschmidt-Leitz and Hesse (*Z. physiol. chem.*, 126, 143, 1923), based on the determination by iodometric titration, of the amount of reducing sugars formed after the reaction, was employed. The particular compound to be tested was added in a concentration (0·1%) which is approximately equivalent to the concentration in the digestive secretions, of a therapeutic dose (10 grains) of quinine. The reaction mixtures were maintained under the optimum conditions with regard to temperature, $p$H, etc. for enzyme action. Contrary to previous reports, the levo-rotatory hydrocupreines were found to be far more powerful inhibitors to the amylases than the dextro-rotatory hydrocupreidines. Quinine comes in between the two groups, being generally weaker than the higher members of levo-rotatory hydrocupreines but stronger than the dextro-rotatory hydrocupreidines. The lower members of the hydrocupreidine series do not appear to possess any inhibitory action at all on invertase activity while the higher homologues are definitely more potent in this regard. The possible mechanism of this inactivation has been discussed.

## 26. Studies on the effects of some cardiac drugs on heart explants.

R. N. CHOPRA, N. N. DAS, *and* B. MUKERJI, Calcutta.

It has been noticed (Murray, 1934) that fragments of heart tissue from Chick embryos (6 to 8 days old) if kept in a nutrient medium containing homologous plasma and embryonic extract, exhibit certain characteristics in the nature of their throbbing and their growth. In the present investigation, the effects of a few well-known cardiac drugs, e.g. lanadigin (crystalline glucoside of *D. lanata*), thevetin (crystalline glucoside of *T. neriifolia*), ouabain (crystalline glucoside of *G. strophanthus*), caffeine and cardiazol, on these heart explants were studied in the hope that the observations on such simple, nerve-free embryonic preparations would throw light on the true mechanism of their action on heart tissue.

The effects on both the (1) fibroblastic growth of cells and the (2) rate of throbbing of the heart tissue were recorded. It was found that both

lanadigin (1 : 500,000) and thevetin (1 : 50,000) stimulate the fibroblastic growth of tissue cells but inhibits the rate of beat of the heart explants. Strophanthin (1 : 4,000,000) does not seem to possess any stimulant effect on the tissue growth but brings about a definite inhibition in the rate of throbbing. Caffeine (1 : 50,000) and cardiazol (1 in 50,000) are both stimulants to the growth of tissue cells as well as to the rate of beat of the cardiac explants. Caffeine further seems to prevent the normal occurrence of fatty degeneration in these explants and maintains the beats for a longer period than the controls kept under identical conditions. The theoretical implications of these interesting results are discussed.

## 27. Pharmacological action of 'skimmianine'—an alkaloid obtained from *Skimmia laureola.*

R. N. Chopra, G. S. Chopra, *and* J. C. Gupta, Calcutta.

An alkaloid skimmianine has been isolated from the leaves of *Skimmia laureola,* a glabrous shrub belonging to natural order Rutaceae. The alkaloid is insoluble in petroleum ether, sparingly soluble in ether and cold absolute alcohol, soluble in hot alcohol and readily in chloroform. The purified alkaloid is obtained is yellow rhombic octahedral crystals melting at 175°-176°C.

The important pharmocological effects of this alkaloid are the rise of blood pressure, inhibition of the tone and movements of the plain muscles of the intestine and constriction of bronchioles. These effects appear to be due to stimulation of sympathetic. It is observed that the action of this alkaloid on the sympathetic is predominant in the case of heart and intestine.

## 28. Antagonism of ergotamine on adrenalin.

B. Narayana, Patna.

The action of ergotamine on the vessels of the hind limbs of the frog was investigated. The results show an uncertain action of the drug on the preparation. Perfusion with adrenaline following ergotamine causes vaso-constriction. There is no evidence that the action of adrenalin is suppressed or reversed by ergotamine.

## 29. On the influence of adrenalin and acetyl-choline on the effects of calcium and potassium ions on the onset of fatigue in skeletal muscles of frog.

N. M. Basu *and* G. C. Mukherjee, Calcutta.

Skeletal muscles of frog were kept bathed in a muscle trough filled with Ringer's solution and stimulated repeatedly by means of a neon-lamp stimulation unit. The effects of adrenalin and acetyl choline and of calcium and potassium ions in different concentrations on such preparations were noted. The results are as follows :—

(*a*) With Ca and adrenalin lack, fatigue is delayed but the contractions are weak and the contraction remainder is slight.

(*b*) Addition of adrenalin or sub-normal amounts of $CaCl_2$ makes the contractions more powerful and causes an early onset of fatigue, whereas, the addition of both causes still more powerful contractions and an earlier onset of fatigue.

(*c*) With further increase in $CaCl_2$ concentration the contractions become more marked but fatigue is delayed. Addition of adrenalin augments these effects.

(*d*) If the concentration of $CaCl_2$ be five times the normal amount, then also the augmented contractions and delayed fatigue are noticed but the addition of adrenalin quickens the onset of fatigue.

(*e*) With K lack, contractions are strong and fatigue is delayed. Addition of KCl quickens the onset of fatigue in proportion to the amount added, but the addition of acetylcholine helps relaxation and delays the onset of fatigue.

(*f*) If the concentration of KCl be nine times the normal amount both contractions and relaxations are reduced, the former more than the latter and the onset of fatigue is much quickened. The addition of acetylcholine to the solution delays the onset of fatigue.

## 30. On the influence of Ca and K ions on the effects of adrenaline and acetylcholine on frog's heart.

N. M. Basu, S. K. Mahalanobis, M. C. Mitra, *and* G. G. Banerjee, Calcutta.

The effects of adrenaline and acetylcholine and the manner in which these effects are modified by the presence or absence of different concentrations of calcium and potassium ions were observed in perfused frog's heart. The results obtained are stated below :—

(*a*) In Ringer deficient in Ca, the heart-beat stops after some time, but the addition of adrenaline prevents this stoppage of heart beat. This action of adrenaline is not seen when an excess of calcium is added to the perfusion fluid.

(*b*) In the absence of Ca acetylcholine is quite effective but with the addition of increasing quantities of Ca the effect of acetylcholine becomes less and less evident. In the absence of potassium however the acetylcholine action does not take place readily.

(*c*) If the vagus nerve is stimulated by a weak and rapidly intermittent current while the heart is being perfused with calcium-free Ringer solution the heart beat is slowed and reduced. The effect of vagus stimulation is not noticeable if a small amount (subnormal) of calcium is added to the perfusion fluid.

(*d*) In potassium free Ringer solution adrenaline augments the heart beat but makes the heart stiff, but with the addition of K, the augmentation effect of adrenaline is less marked and the stiffness of heart does not result.

## 31. On the effects of adrenaline, histamine, phloridzin and cobra venom on blood vessels.

N. M. Basu *and* G. C. Mukherjee, Calcutta.

These experiments were performed on frogs by the vessel perfusion method which has been slightly modified in accordance with the needs. The rate of outflow was measured by a thermionic drop recorder and tracings were taken. The known effects of adrenalin were compared with those of phloridzin, histamine and cobra venom. It was found that whereas adrenalin brings about immediate constriction of blood vessels, phloridzin causes constriction after some time. The effect of adrenaline is temporary but phloridzin effect is more lasting. Histamine brings about vaso-dilatation immediately and this effect is temporary. Cobra venom has no effect on the tone of blood vessels.

## Biochemistry

### 32. Total ascorbic acid content of human blood.

S. K. GOKHALE, Bombay.

The blood of eighty normal young Indian males has been examined for the total ascorbic acid content. The method of Mirsky, Swadosh, and Soskin (Proc. Soc. Exp. Biol. Med; 1935, *32*, 1130) was used. The procedure converts any oxidised material into the reduced form and this enables the determination of the total content of ascorbic acid present in the reduced form. Fasting blood samples were used. The values obtained gave a mean average of 1·80 mg. per 100. c.c of blood, with a range of 1·20–2·54 mg. per 100 c.c. The subjects were young medical students mostly from the Bombay Presidency of ages between 18 and 32 years. The results obtained showed that the mean total ascorbic acid content of those on vegetarian diet did not differ significantly from that of those on mixed diet.

### 33. Actinomyces—their biochemical reactions as aids in their classification, Part I. Reduction of nitrates.

L. M. GHOSH, S. GHOSH, N. R. CHATTERJEE, *and* A. T. DUTT, Calcutta.

The classification of the group of micro-organisms, generally designated as actinomyces, is still very unsatisfactory, and various authors have put forward various schemes of classification based on the morphology, clinical characters, physiological properties, etc. A study of the biochemical property of the reduction of nitrates of about 31 species of actinomyces in Czapeck's synthetic liquid media, without the use of iron salts, has been made. These have been found to fall into three main groups. A modified scheme of classification is suggested and it is believed that further studies on this and other biochemical reactions will give more significant data for a better and more satisfactory classification.

### 34. Some biochemical findings in cases of anæmia of pregnancy and in normal pregnancies in Bengal.

H. N. CHATTERJEE *and* S. M. GHOSH, Calcutta.

Pregnancy anæmia in Indian women is not primarily a hæmolytic anæmia as shown by the Van den Bergh test and estimations of bilirubin although in the later stage of the disease the Van den Bergh test might indicate some amount of hæmolysis. The condition has a seasonal variation in Bengal. It starts with the rains and has the maximum intensity during the height of the rainy season.

It is possible that an excessively moist atmosphere interferes with the excretory function of the skin and thereby puts an additional burden on the kidney which has already to perform an extra amount of work in pregnancy. There is also a decrease of the serum albumin and the absolute increase of the serum globulin with a disturbed albumin : globulin ratio. This changes the osmotic pressure of the plasma and might be instrumental in the production of the associated œdoma. The disturbed albumin : globulin ratio is also present in some of the normal pregnancy cases examined.

A very remarkable feature is the marked decrease in blood cholesterol (instead of the normal increase) which might inhibit the formation of the red cells of whose stroma it is an important constituent. There is a possible vicious circle and correlation between the low blood cholesterol and the retention of nitrogenous products and chlorides, in other words,

between the bone-marrow and the kidney functions aggravating each other and resulting in progressive anæmia and œdema.

## 35. Some observations on the incidence of malocclusion of teeth in Indian children of all communities.

H. ELLIS C. WILSON *and* D. D. MITRA, Calcutta.

The incidence of malocclusion including displaced and rotated teeth has been studied in some 3,000 children of both sexes. As regards the different communities the highest percentage was found among the Anglo-Indians followed by the Marwaris, Hindus and the Moslems. Taking any one community the highest incidence was observed among the poorer class. It would appear that probably diet alone is not the only factor. There does not seem to be any correlation between caries and malocclusion. In general those with malocclusion showed no signs of caries. In any one community of the same economic class there did not appear to be any difference between the sexes.

## 36. Glutamic acid dehydrogenase from germinating seeds.

MANAYATH DAMODARAN *and* K. RAMAKRISHNAN NAIR, Madras.

In view of the hypothesis recently advanced by Krebs on the part played by glutamic acid deaminase in the synthesis of glutamine in animal tissues, the existence of deaminases in seedlings was investigated, as in the latter, amide-synthesis is a well-established fact. A specific glutamic acid dehydrogenase has been detected in some seedlings of the leguminous family; but only in three out of a dozen species examined could its presence be demonstrated.

The enzyme belongs to the group of 'oxytropic dehydrogenases' reacting with substrate either in the presence of oxygen or of methylene blue. It can be obtained in cell free extracts and can be concentrated by precipitation with ammonium sulphate (full saturation). It has an optimum pH of 7·8 and is wholly inactive below pH 5·9.

In manometric experiments the rate of oxygen uptake is not influenced by hydrogen carriers like methylene blue, ascorbic acid, glutathione, or 1–3·4 dihydroxy-phenylalanine. Potassium cyanide or arsenite up to a concentration of ·002M has no inhibitory action, but with higher concentrations the oxygen uptake falls slowly though inhibition is not complete even at a cyanide concentration of 0·2M.

The oxygen utilised corresponds to one atom of oxygen per molecule of glutamic acid. The product of the oxidation has been shown to be α-keto-glutaric acid which was isolated as its 2·4-dinitro-phenylhydrazone.

## 37. The rôle of carotene in metabolism of fats. Part I.— Seasonal variation of Reichert value, iodine number, carotene and vitamin A contents of butter fats.

S. M. DAS GUPTA, Calcutta.

About 4 to 15 samples of butter fats prepared in each month were analysed for their Reichert value, iodine number, carotene and vitamin A contents. It was observed that the Reichert values and carotene contents on the one hand and iodine number and vitamin A contents on the other tend to be higher in the winter (November to February) than in the autumn (July to October). *Prima facie*, the results obtained are contradictory to the data obtained in western countries where the lowest Reichert values and carotene contents of butter fats have been obtained in the winter. The explanation of this is probably to be found in the

grazing habits of the cattle in this country and the availability of grasses and leafy vegetables of high carotene content during winter.

### 38. The rôle of carotene in the metabolism of fats, Part II.

S. N. DAS GUPTA, Calcutta.

It is generally held that the first stage in the metabolism of fats is the desaturation of the fatty acids and then oxidation takes place by the well-known process of beta-oxidation. The constitutional formula of carotene at once suggests that it can act as a hydrogen acceptor in the process of desaturation or as an oxygenated compound in the process of oxidation. Moreover, Euler and his school consider that vitamin A is a reduced fragment of carotene. If such be the case, then the processes of desaturation and oxidation of fatty acids are closely connected with the carotene and vitamin A contents of butter fats. To test this dual function of carotene, feeding experiments have been carried on two healthy cows with rations of high and low carotene contents resembling those of the autumn and the winter feeding-stuffs. It has been found that by ingesting fresh grass of high carotene contents (3·6 mg. per 100 gm.) the Reichert value gradually rises (from 26·2 to 28·6) but again falls when the cows are again fed on hay The results obtained are in close agreement with the hypothesis suggested above.

### 39. Investigation of vitamin $B_1$ and $B_2$ content of Soya bean (*Glycine hispide*) by biological method.

K. P. BASU *and* MD. ABDUL QUADER, Dacca.

Black type of soya bean was investigated in three percentages—15% ; 25% : 40% in the diet for vitamin $B_1$ and $B_2$ determination by biological method. The value for $B_1$ has been found to be 165·59 international unit per 100 gms. of soya bean. Soya bean contains a fairly good amount of $B_2$. The behaviours of the individual rats on different percentages of soya bean content are shown in graphs.

### 40. Biological value of proteins of 'Arhar' (*Cajanus indicus*) and black gram (*Phaseolus mungo*, var. Linn) by balance sheet method and by growth of young rats.

K. P. BASU *and* MD. ABDUL QUADER, Dacca.

The biological values of 'Arhar' (*Cajanus indicus*) proteins by balance sheet method at 10 and 15% levels of protein conconcentration are 54 and 48 respectively, while those of *Phaseolus mungo* at the same levels are 75·8 and 65·9. The biological values thus decrease with increase of concentration of protein.

The protein values of *Cajanus indicus* at 10 and 15 per cent. levels of protein are 12·8 and 10·34 respectively while those of *Phaseolus mungo* are 21·44 and 17·08 respectively.

Growth per gm. of protein ingested at 15% protein concentration in the case of *Cajanus indicus* is 0·89 and of Phaseolus mungo 1·09, while that at 10 per cent. concentration in the case of *Cajanus indicus* is 0·69 and in the case of *Phaseolus mungo* 0·85.

### 41. Deficiency of calcium and phosphorus in average Bengalees.

S. K. SEN, Calcutta.

The amount of calcium in the serum does not throw any light regarding its amount in the bone reservoirs. In an average Bengalee

adult its concentration in serum is nearly normal, but the bone shows a marked deficiency in both calcium and phosphorus. The estimation of calcium in human as well as cow's milk also gives figures lower than the accepted normal. The possible causes for such low figures have been discussed.

## 42. A comparative study of glycolysis in normal and diabetic blood.

PREMANKUR DE *and* SUKUMAR BHATTACHARYYA, Calcutta.

The rate of glycolysis in oxalated blood in normal and diabetic cases was studied. Glycolysis takes place in drawn normal oxalated blood at a rate of 3·83–6·50 mgm. per hour per 100 c.c. of blood (average 6·05 mgm. per hour per 100 c.c.) during the first 4-5 hours of observation. In oxalated diabetic blood, glycolysis proceeds at a rate of 4·0–16·6 mgm. per hour per 100 c.c. of blood (average 4·61 mgm. per hour per 100 c.c.) which indicates a depression of about 23·8 per cent. from the normal blood. This high rate however falls after 4 to 5 hours when glycolysis proceeds at a continuously decreasing rate.

## 43. Glycolysis in drawn blood in 24 hours.

PREMANKUR DE *and* SUKUMAR BHATTACHARYYA, Calcutta.

Complete glycolysis does not take place in 24 hours in oxalated blood. The percentage of sugar glycolysed is found to bear a more or less inverse ratio to the initial sugar concentration. Accumulation of lactic acid has been suggested as the probable cause of diminution of glycolysis in later periods.

The amount of non-glucose copper-reducing substances in blood has been found to be about 6–8 mgm. per 100 c.c. of blood.

## 44. The influence of ingestion of ascorbic acid on the vitamin C content of milk.

M. N. RUDRA, Patna

It has been found that by allowing a goat to ingest large amounts of ascorbic acid (5 to 22·5 mgs. per kg. body weight), the vitamin C content of its milk could be raised by about 50 per cent. When the goat was put on a vitamin C free diet for 7 days, the milk was about normal in vitamin C content as during grazing. A dose of 50 grams. of glucose for 15 days now raised the vitamin C content of milk.

## 45. A study of the exchange of dissolved substances between a voluntary muscle and saline solutions.

A. GAFFAR, Nagpur.

When a muscle is immersed in a saline solution, an exchange of substances dissolved in saline and the muscle water takes place, till an equilibrium is established between the two. The composition of the saline, while keeping it osmotic with the muscle, may be varied by adding various substances to it, and thus the diffusion of various substances into and out of muscle can be studied. By suitable calculations, the ratio between the portion of muscle-water into (or out of) which a substance can diffuse, and the portion which does not allow such an exchange can be determined.

This method has been employed in studying the rate of diffusion of urea, bicarbonate, histidine, lactate, iodide, etc. through the living

voluntary muscle of frog. The results indicate that these substances may be divided into two groups : (A) substances that can diffuse through the whole of muscle water, e.g. urea, histidine and carbon dioxide. (B) substances that can diffuse through a portion of muscle water ('interspace' water) only but is unable to diffuse into the rest of it ('cell' water). To this group belong lactate, iodide, chloride, bicarbonate, etc. Further, in every case it is found that 'interspace water' forms about 1/3 and the cell water about 2/3 of the total muscle water.

## 46. The action of choline in the prevention of fatty livers produced by anterior pituitary extracts.

B. Mukerji *and* R. C. Guha, Calcutta.

Best and his co-workers (1932–1936) made the interesting observation that the feeding of choline chloride prevents the marked increase in the concentration of liver fat which occurs in rats on fasting, on cholesterol feeding and by diets rich in fats. They further observed that the injection of anterior pituitary extracts causes a considerable deposition of fat in the livers. In this communication, an attempt has been made to see whether the feeding of choline prevents the increase of liver fat produced by the injection of anterior pituitary extracts.

Three groups of rabbits were kept on a standard diet and treated as follows :- (*a*) Normal controls without any injection, (*b*) injection of anterior pituitary extract ; (*c*) choline feeding (500 mg/kg.) for 8 days and anterior pituitary injections. The rabbits were killed 20 hours after anterior pituitary injections and the content of liver fatty acids and their iodine numbers were determined. The average fatty acid content following injections of anterior pituitary extract was 6·50 per cent. The animals fed with choline chloride did not show any significant diminution in the concentration of liver fatty acids (5·82 per cent.) and there was no noticeable difference in the iodine numbers. It seems probable that the mechanism by which fatty livers are produced by injections of anterior pituitary extracts may not be the same as that responsible for causing fat deposition after cholesterol and fat feeding. The theoretical implications of these possibilities have been discussed.

## 47. The relative composition of blood and lymph in filarial infection.

R. N. Chopra, S. Sundar Rao, *and* S. N. Mukherji, Calcutta.

Estimations have been made of various components such as cholesterol, fatty acids, inorganic and organic phosphorus, albumen, pseudo-globulin and euglobulin of blood and lymph obtained from patients in different stages of filarial infection and the results are discussed. An appreciable increase in the cholesterol content of the blood of the affected persons is noticed. The lymph in filarial diseases appears to be exceptionally rich in proteins in relation to blood serum and is strikingly different in this respect from lymph obtained from cases of œdema due to other causes.

## 48. Ionisable iron in Indian food-stuffs.

J. C. Pal, K. L. Roy, *and* B. C. Guha, Calcutta.

Although iron has been estimated in some Indian food-stuffs and dietaries, there is no record yet of the percentage of ionisable iron present, which is more important from the nutritional standpoint. The estimation of ionisable iron has, therefore, been carried out in a number of Indian food-stuffs and dietaries and it has been found that its content is consider-

ably low compared with the total iron content. In the estimation of the value of a food-stuff, the ionisable iron content should receive major consideration, as on this will depend the absorption and utilization of iron in the body tissues.

## 49. A study of the dietary habits of some communities living at Calcutta.

D. D. MITRA, Calcutta.

In this paper an attempt has been made to find out statistically the number of times of consumption of some common articles of food per boy per day, amongst the four chief communities residing in Calcutta, viz : Bengali Hindus, Marwaris, Mahommedans and Anglo-Indians. The boys in general belong to the better off classes of their respective communities. The comparison has been made in terms of the 'daily index' which has been taken as the ratio of the number of times of daily consumption of a particular item of food to the number of children consuming it.

Data have been collected regarding nine common dietary constituents, viz. (i) rice, (ii) bread, (iii) pulses, (iv) vegetables, (v) fruits and nuts, (vi) milk and milk preparations, (vii) fish, (viii) eggs, and (ix) meat. A few typical examples of the maximum indices obtained are given below :—

Rice—1·6 (Bengali Hindus) ; bread—2·8 (Anglo-Indians) ; pulses—1·5 (Bengali Hindus) ; vegetable—2·4 (Bengali Hindus) ; fish—1·4 (Bengali Hindus) ; meat—1·3 (Mahammedans and Anglo-Indians).

It appears, among other points, that the Mohammedans and the Anglo-Indian boys take less often the pulses and vegetables and more often meat, fish and eggs than the Hindu boys.

## 50. Vitamins $B_1$ and $B_2$-content of a few common preparations of rice.

H. G. BISWAS, Calcutta.

*Chira* (flattened rice), *Khai* (fried paddy) and *Muri* (fried rice) are important preparations of rice, widely used as supplementary diets by the masses of Bengal.

The biological assay of vitamins $B_1$ and $B_2$ of these food-stuffs was conducted on young albino rats. Five rats of each group deficient in vitamins $B_1$ and $B_2$ respectively were put on 2 grams. of each sample daily for 3 weeks and the average weekly growth was determined. The amount which fed daily to the deficient rats produces a weekly gain in weight of 10 g. for the above period, is regarded as the unit of these vitamins.

It was found that (1) (*a*) 100 g. country-made *Chira* from a coarse variety of *Aman* paddy gave 34·5 units Vitamin $B_1$ and 18·5 units Vitamin $B_2$. (*b*) 100 g. local fine *Chira* gave 22·5 units $B_1$ and 12·5 units $B_2$. (2) 100 g. local *Muri* gave 14·5 units $B_1$ and 11 units $B_2$. (3) 100 g. local *Khai* gave 13 units $B_1$ and 14 units $B_2$. Experimental details are given in the paper.

## 51. Nutritive value of the proteins of *Ruhee* (*Lobeo Rohita*) and *Hilsa* (*Clupea Ilisa*) by nitrogen alance bmethod.

K. P. BASU *and* H. N. DE, Dacca.

An attempt has been made to estimate the 'biological value' and digestibility of the proteins derived from two common edible fishes available in Bengal under different conditions of treatment, e.g. steam-drying and sun-drying. It is found that the biological value of steam-dried *Ruhee* meal at 5, 10, and 15% levels of intake are 84, 78·8 and 73·3. The corresponding values for the steam-dried *Hilsa* are 78·6, 69·6 and 60·5. The biological value decreases with increase in the concentration of the protein.

There is no change in the digestibility of the protein. Biological value as well as the digestibility increases when the meal is prepared by drying in the sun. Lower biological value and digestibility in the case of steam-dried product is due to the effect of temperature on the quality of proteins. *Ruhee* fish is superior to the *Hilsa* fish as regards biological value as well as digestibility of its protein under both processes of preparation of the meal.

The supplementary effect of the *Ruhee* fish protein on the proteins of the pulses—*Lathyrus sativa* and Lentil is also observed. The protein values of *Ruhee* and *Hilsa* fish proteins under both processes of drying the fish at 10% level of intake are as follows :—

| | | | |
|---|---|---|---|
| Steam-dried *Ruhee* | 16·72 | Steam-dried *Hilsa* | 10·98 |
| Sundried *Ruhee* | 19·46 | Sundried *Hilsa* | 13·13 |

## 52. Nutritive value of the proteins of *Ruhee* (*Lobeo Rohita*) and *Hilsa* (*Clupea Ilisa*) by the growth of young rats.

K. P. Basu *and* H. N. De, Dacca.

Proteins of steam-dried *Ruhee* and *Hilsa* were fed at 5, 10, and 15 per cent. levels of intake. The growth per gram of protein at 10 and 15 p.c. levels are 1·55 and 1·86 in the case of steam-dried *Ruhee*, and 1·32 and 1·51 in the case of steam-dried *Hilsa*. When the protein of the diet is at 5 p.c. level, the value for *Ruhee* is 1·46 whereas in the case of *Hilsa* no growth is observed.

Rats on sundried *Ruhee* and *Hilsa* meal at 10 p.c. protein concentration show greater growth than those on steam-dried meals at the same level of intake. For the growth of young rats, however, *Ruhee* fish protein is immensely superior to that of *Hilsa* fish at all processes of drying. There appears to be a distinct difference in the rate of utilization of the proteins by male and female. This may be explained by the more rapid growth of male rats as compared with the female rats.

Marked supplemental effect of the *Ruhee* fish protein on the proteins of pulses as *Lathyrus sativa*, Field-pea, Green gram and Lentil is observed and this is of great practical importance in human dietetics. The maintenance requirement for rats varying from 50 grm. to 60 grm. of body weight appears to be 4 grm. of protein from these two pulses for a period of 8 weeks.

## 53. Determination of the Vitamin A content of the liver and body oils from *Ruhee* (*Lobeo Rohita*) and *Hilsa* (*Clupea Ilisa*) by the biological method.

K. P. Basu *and* H. N. De, Dacca.

The Vitamin A potency of the liver oil is higher in *Ruhee* fish than in *Hilsa*. The international units of Vitamin A contained in one grm. of the liver oils of *Ruhee* and *Hilsa* are 461 and 119 respectively. The potency of one grm. of the body oil of *Ruhee* is 127 international units while that of the *Hilsa* body oil is nil. The figures for unit values are computed by comparison with the International standard of Vitamin A (carotene) obtained from the nutritional research laboratory at Coonoor, South India.

## 54. The chemistry of bone extract.

C. A Rothenheim *and* S. S. Cowlagi, Bombay.

The paper deals with the preliminary results of the chemistry of an extract prepared from bone, blood and blood serum. The extract has the property of hastening the healing of broken bones where the natural process is slow. It also stiffens pseudarthrosis. Preliminary results show

the presence of Na, K, P, and C, but the absence of histamin, or thyramin and of the already known bone ferments.

### 55. Biochemical studies in monkey hæmoglobinuria.

K. V. Krishnan *and* N. G. Pai, Calcutta.

Samples of blood from monkeys (splenectomised and non-splenectomised) infected with *P. knowlesi* were examined during the following stages of infection:—(1) normal state, (2) after splenectomy. (3) after infection and during incubation period, (4) during parasitological period, (5) final reading prior to the onset of either (*a*) hæmoglobinuria and death, or (*b*) non-hæmoglobinuria and death, or (*c*) cure. The constituents examined were: (1) cholesterol—total, free and ester, (2) total fatty acids, (3) phosphorus derivatives soluble in alcohol-ether mixture, e.g. lecithin and allied compounds classified as organic phosphorus, (4) inorganic phosphorus, (5) glucose. The results obtained showed that before the onset of hæmolysis and hæmoglobinuria, there is—(1) generally a fall in total cholesterol, (2) a rise in ester cholesterol indicating the production of fatty acid in the system, (3) *a marked fall in free cholesterol*, (4) a rise in inorganic and organic phosphorus, and (5) a marked fall in blood sugar. These results, specially No. 3, were characteristically different from those obtained for monkeys not developing hæmoglobinuria. Although hæmoglobinuria in monkeys is not completely similar to blackwater fever in man, the results suggest that the hæmolysin involved in human blackwater fever may be of the type of an unsaturated fatty acid which acts when free cholesterol is low.

## Anatomy

### 56. The fate of the Duct of Cuvier in man and certain other mammals.

M. A. H. Siddiqi *and* R. V. Singh, Lucknow.

The large venous trunks in man and in eleven different types of mammals have been investigated. The arrangement of veins in the region of Superior Vena Cava and the coronary sinus has also been studied.

As a result of this investigation it is observed that three definite types of arrangement exist. These have been discussed from embryological standpoint.

### 57. The knee-joint in the climbing Marsupials.

B. M. Lal, Hyderabad (Deccan).

Three specimens were dissected—*Dasyurus viverrinus*, *Didelphys Avrita*, and *Dendrolagus Innatus*.

In all cases, the proximal surface of the head of the fibula takes part in the formation of the knee-joint, and articulates with the lateral condyle of the femur. There is considerable movement between tibia and fibula at the proximal tibio-fibular joint. The joint is capable of forward and backward movement and a certain amount of rotation. As the fibula is in contact with the lateral condyle of the femur during the flexion of the knee-joint, when the tibia and fibula are forcibly pressed together by the action of the popliteus and the tibio-fibular interosseous muscle, the forward and inward movement of the fibula causes the knee-joint to extend with considerable force. This action is necessary in these animals on account of a feeble cartilaginous patella, which is unable to give sufficient leverage to quadriceps femoris. The extension thus started is carried on by the external or fibular collateral ligament dragging the

femur above the axis of rotation after the advancing head of the fibula. The movement at the proximal tibio-fibular joint and the articulation of the head of the fibula with the lateral condyle of the femur is a vestige of the reptilean joint. Popliteus muscle does not gain origin from the lateral condyle of the femur, but only from the proximal part of the fibula and the action of the muscle is not of flexion, but rather pronation. The muscle is continuous with the lateral meniscus of the knee-joint indicating the derivation of the ligament from that muscle.

The knee-joint is primitive in these marsupials in the following respects :—

1. The head of the fibula articulates with the lateral condyle of the femur and takes part in the formation of the knee-joint.
2. There is movement between the fibula and the tibia in the proximal tibio-fibular joint.
3. The patella is cartilaginous.
4. Some of the ligaments are doubled.
5. The rotular surface of the femur is shallow or flat.

## 58. Some features of interest in the posterior limb of 'Paradoxurus Niger' commonly known as 'Bijju'.

B. M. Lal, Hyderabad (Deccan).

The mesogluteus and ectogluteus muscles have a caudal origin and are associated with the muscle Ischiofemoris which possesses caudal and ischial heads of origin. Hamstring mass possesses the caudal head, Flexor Caput dorsale which arises from the vertebræ and joins the Semitendinosus muscle. The Ectogluteus muscle and Adductor Magnus and Tensor Fascia lata are laminated. The Tibialis posterior, the tibia and fibular flexors form one muscular mass.

The chief primitive characters in the animal are : lamination of some of the muscles ; absence of the origin of ectogluteus muscle from the ilium ; survival of the caudal head of origin of flexor cruris muscle ; presence of Ischiofemoris and Tenuissimus muscles, and undifferentiated soleus muscle and a very large Plantaris muscle.

## 59. Development and abnormalities of the heart.

H. Hyder Ali Khan, Hyderabad (Deccan).

The pericardial area is a mass of Mesoderm situated in the extreme cephalic end of the embryo (Fig. 1). Two primitive Aortae appear in this region and are joined by vitelline veins from the yolk-sac and the umbilical veins. As the embryo is bent the pericardial area is brought down and the primitive aorta is also bent giving rise to the ventral aorta, the first arch and the dorsal aorta. The caudal portions of the two ventral aortæ fuse together to form a heart tube which receives the vitelline veins, the umbilical veins, and the precardinal and postcardinal veins from the cephalic and caudal portion of the body unite into a single trunk called the Duct of Cuvier (Fig. 2). The heart tube contracts rhythmically and maintains the circulation. Constrictions divide the heart tube into the truncus arteriosus, bulbus cordis, ventricle, atrium and sinus venosus (Fig. 3). The truncus arteriosus splits into the pulmonary artery and the ascending aorta ; the bulbus cordis and ventricle from the mature ventricle, and the atrium and the sinus venosus become the mature atrium. Two elevations the endocardial cushions grow in the atrial canal from the septum intermedium and divide the canal into right and left (Fig. 4). Septum primum grows into the atrium and joins the septum intermedium ; the opening between the two is called the ostium primum of Born. Before the opening is closed another opening ostium secundum of Born is formed in the septum pri-

mum. The development of septum secundum acts as a flap valve till birth and allows blood to flow from right to the left atrium only. This opening is foramen ovale. After birth the two septause and the foramen ovale is closed. The ventricle is divided into right and left by the crescentic septum inferius which develops upwards (Fig. 5). Four endocardial cushions appear in the bulbus cordis, the two lateral again divide into two each. The ventral pair together with the ventral cushion form the pulmonary valves and the dorsal pair together with dorsal endocardial cushion form the aortic valves (Fig. 6). The atrioventricular valves are derived from the septum intermedium medially and the invagination of the atrial canal laterally.

*Abnormalities. (In position.)* The heart may fail to descend (cervical heart), may pass in the abdomen through a diaphragmatic hernia, may be situated on the right side, doxtrocordis (accompanied by transposition of the viscera), thoracic wall being deficient—ectopia cordis.

*(In structure.)* Abnormality may effect the septum, the openings, the valves or the great vessels, such abnormalities being multiple. Incomplete development of the interatrial septa (patent foramen ovale) is usually accompanied by a patent ductus arteriosus and stenosis of the pulmonary artery. Deficiency in the septum inferius (with only one ventricle). Deficiency of valve due to incomplete development of endocardial cushions. Over-development of the endocardial cushions causes stenosis. The main vessels may be absent or transposed and lastly the ductus arteriosus may remain patent.

These conditions, though usually serious, sometimes do not cause any symptoms during the early age. The case of S.B. aged 10 with clinical signs of pulmonary stenosis caused no untowards symptoms nor was there any marked hypertrophy of the right ventricle (Fig. 7). Electrocardiogram.

## Miscellaneous

### 60. A simple method of staining reticulocytes.

C. R. DAS GUPTA, Calcutta.

The enumeration of reticulocytes is of great value clinically as it is a helpful adjunct in the diagnosis of different types of anæmia. Prognostically also this is of great help as the count offers a most valuable means of estimating the therapeutic activity of any hæmatinic medication.

To demonstrate the reticulation in the immature erythrocytes, brilliant cresyl blue is the dye of choice. The following technique has given satisfactory results in the hands of the writer. An equal amount of oxalated blood and 1% brilliant cresyl blue in 0·85% NaCl is mixed together in a test tube. A small drop of the mixture is put on a grease-free scrupulously clean slide on the top of which an equally clean coverslip is put—the pressure of the coverslip will give an evenly spread smear. It is now sealed with melted wax and examined in the usual way. With this method there is no clumping, crenation of breaking down of the cells and the reticulocytes stain very well giving a much higher count than the counts obtained by ordinary methods.

### 61. Adsorption of hydrogen ions by serum globulin and its antibody.

M. M. BISWAS, Calcutta.

Titration curves have been drawn with pure pseudoglobulin of normal horse serum and its antibody using N/10 solutions of hydrochloric and oxalic acids, baryta and caustic soda. Both the globulins adsorb $H^{\cdot}$ ions from the acids in a parallel way. Above $pH = 5{\cdot}0$ titration with baryta shows no abnormality; whereas the behaviour with sodium hydrox-

ide suggests that normal globulin possesses a stronger affinity for H· ions than the antibody globulin at a higher level of pH than the isoelectric point. This abnormality has been attributed to a differential behaviour of the globulins probably due to certain characteristic end-groupings developed in the antibody during the process of immunization.

## 62. Rôle of formalin in the estimation of nitrogen in body fluids.

PREMANKUR DE *and* C. C. CHATTERJEE, Calcutta.

In estimating urea, non-protein nitrogen, albumin, etc., the nitrogen is first converted into ammonium salts, and from this ammonium salt the amount of the original substance can be calculated. When a neutral solution of formalin is added to a neutral solution of ammonium salt, an equivalent amount of acid is liberated. This acid is titrated by a standard alkali and from the result of this titration the nitrogen present in the material is calculated. This process has been used as a substitute for Nesslerization and also for controlling the result of back-titration. The method is quick, economic and easily controlled and gives equally accurate results.

# SECTION OF PSYCHOLOGY

*President* :—G. Bose, D.Sc., M.B. F.N.I.

## Sensation, Perception and Memory

### 1. D.L. for lifted weights increased continuously.

Gopeswar Pal, Calcutta.

The problem has been approached in two different ways: (1) Standard weight which was lifted by observers was increased continuously at definite rates till just noticeable difference was reported. D.L. values were calculated from the rate of increase and the time that elapsed before difference could be just apprehended. (2) Standard weight was increased continuously at definite rates till it reached definite amounts. Judgments of 'yes' or 'no' regarding increase in heaviness were recorded after the end of each experiment. D.L. values were calculated from 'yes' judgments using the constant process.

The chief findings are as follows: (1) With the increase of the rate of change, D.L. value rises gradually. It reaches its maximum when the rate becomes medium, after this the value falls gradually and it attains its minimum when the rate attains its maximum limit. (2) D.L. values obtained by the ordinary method are lower than the values obtained by the present method. (3) Ratios of D.L. values to standard weights have not been found to be constant.

An attempt has been made in the paper to explaint he reasons of the different findings chiefly in terms of attention and muscular adjustment.

### 2. Psychology of illusion.

S. N. Roy, Patna.

In this paper an attempt has been made to disprove the theory that illusion is false perception. Strictly speaking, 'right' and 'wrong' are terms which are not applicable to perception, and if we do apply them we go beyond the scope of psychology proper. It has been also pointed out that no sharp line can be drawn between right and wrong perception, because every perception involves at least a minimum of illusory experience. The object of perception is determined by the act of meaning which perception involves and this act of meaning is determined by a mental set and as such the object meant cannot be said to be identical with the 'thing'.

Perception may be treated as the function of a total situation and the object of perception as determined by this function. The mathematical notion of function can be conveniently applied to perception and thereby the variable factors can be adequately explained.

### 3. The effect of attitude on the pressure or contact sensation.

K. C. Mukherji, Dacca.

An attempt has been made in this experiment to determine the influence of active and passive attitudes of mind on the continuation of

contact sensation and of its after-effects. The results obtained in this experiment are categorically the same as found by Hayes, Dimmick and Swindle. But their experiments were of a different nature in which the causes of the results were not at all revealed.

### 4. Peculiarities in tactual adaptation.

S. K. Bose, Calcutta.

Duration of tactual sensation and conditions for its persistence and disappearance have been studied in co-operation with untrained and highly trained subjects by placing weights of various dimensions on different parts of the hand. Introspective account reveals interesting peculiarities in adaptation.

### 5. Different levels of errors in memory reproduction.

J. K. Sarkar, Muzaffarpore.

Experimental results clearly indicate two levels of errors in reproduction. A high correlation is found to exist between the nature of the lower type of errors in reproduction and persistence. The higher level definitely shows non-persistence. A close association between non-persistence of errors and intelligence has been established. Besides the above two types of errors, the study indicates the existence of other types which involve the features of persistence and non-persistence in different proportions. The paper concludes with a suggestion about the probable cause of different types of errors.

## Emotion

### 6. A further note on the judgment of facial expression of emotions.

N. S. N. Sastry, Mysore.

The paper is a modification (in regard to experimental procedure only) and continuation of a similar one submitted last year.

The previous investigations on judgment of emotional expressions show that the situation element in the case of an emotional expression has not been sufficiently emphasized.

Twenty-four photographs of emotional expressions (Feleky) were presented to 124 subjects. Correct number of responses, when unaided by titles and aided by such titles, were noted down. The average percentage of success is only 34.

Fifty patients were asked to indicate 10 objects or situations which could serve as stimuli for the 24 emotional expressions. The frequency of such situations or objects was worked out. This served as the basis of a test that was built. The subjects were asked to match the photos with the situations printed. Correct responses came to 85%. So the superiority of the second test over the first one is

$$\frac{85-34}{34} = 1.5.$$

The fact that situation should thus help correct judgment makes one believe that the judgment is a result of deduction from situation.

7. Further study on the induction of emotional states in laboratory experiments.

M. N. SAMANTA, Calcutta.

In a preliminary report on the study of emotion by the pneumographic method, the tentative conclusion was drawn that emotion is best induced in the laboratory by musical notes. The records obtained under musical stimulation, however, showed variations in two opposite directions even in the same emotional state. In some the respiration became rapid while in others it slowed down. An attempt has been made in this paper to explain these phenomena.

## Fatigue

8. Affective influences in mental fatigue.

C. S. MYERS, London.

In the isolated striated *muscle* fatigue is ascribed : (*a*) to the exhaustion of intra-cellular material essential for its contractility, (*b*) to the accumulation of the toxic products of its activity. But in the intact living organism such muscle is largely safeguarded initially from (*a*) and (*b*) by inhibitory, afferent impulses, mainly reflex and proprioceptive.

Is it not therefore likely that the observed effects of prolonged *mental* activity are due initially not so much to fatigue in the corresponding senses of (*a*) or (*b*) as to the protective actions of affective mental processes ? It is recognized that instinctive activities are maintained by various emotional affects : anger, for example, prevents any other conative process from interfering with combat. So too, voluntary attention, essential for conscious intellectual activity, is maintained by the affective factor of interest, spontaneous or enforced. With prolonged attention, the feelings first of boredom, later of weariness, replace the feeling of interest It is suggested that each of the two former exercises an inhibitory function on attention, protecting it against true fatigue. These afferent inhibitions may conceivably spread so as to terminate the previously successful repression from consciousness of conflicting 'complexes' and to arouse, consequently, feelings of irritation, worry and anxiety, all preventive of the normal exercise of attention and leading to disorderly and uncoordinated mental and outward behaviour.

9. Psychological significance of ergographic curves.

H. P. MAITI, Calcutta.

Psychological study of ergographic curves has considerably suffered from a physiological bias in the past. The present study is a continuation of a paper contributed to a previous session of the Indian Science Congress (1935) and entitled 'Ergograph as a diagnostic aid in Psychiatry'. It shows that an ergogram has individual characteristics which remain more or less constant and which can be interpreted psychologically. A comparative study of ergograms of normal and mentally diseased persons is attempted.

10. A study of 'big muscle' ergographic curves.

ANATHNATH DATTA, Calcutta.

(Communicated through G. Bose.)

An attempt has been made in this paper to study some of the peculiarities of the ergogram as recorded in Big Muscle Ergograph devised by Dr. G. Bose. A comparative study has also been made to show the difference in the nature of the work of the big muscles and small muscles.

## Education and Mental Tests

### 11. The nature of 'M' factor.

K. G. R. RAO, Madras.

A factor analysis of Cox's tests of mechanical ability, as best representing mechanical ability tests in general, may be expected to throw light on the nature of 'M' factor.

Cox and others have isolated a group factor, 'M', running through tests of mechanical ability. This factor has been differently explained by other workers as 'mechanical intelligence', 'spatial ability' and a differential influence of 'experience'.

The present study involving factorization of Cox's tests has shown evidence of the presence of three factors of varying magnitude They are · 'g' measured by the non-verbal primarily perceptual tests, a verbal factor, and a factor 'M' which is observed for boys only. It is suggested here that this factor 'M' is attributable to a special experience reserved for boys only—a special interest in toys and models of mechanical kind.

A reference is made to the possible bearing of the result upon school work.

### 12. A comparative study of scores in selected items of Terman's 'logical selection' and Burt's 'reasoning' (modified) tests.

S. JALOTA, Lahore.

The answers of 1,856 students have been considered in this paper.

The comparison is based upon the values of (i) inter-correlation and (ii) the deviation from normality (Pearson's $\beta_2$).

The correlations between the scores in logical selection and reasoning are low, ranging from +·178 to +·495. But the correlations of the above tests with the total-score for the test-battery are fairly high (+·6 to +·8). The correlation value of reasoning with the 'totals' is uniformly higher. The reasoning-scores also show better normal distribution. It is argued therefore that the two items are tests of very different mental abilities If Burt's items be taken to agree with normal reasoning situation, then it follows that Terman's 'logical selection' is a misnomer.

### 13. A short report of group intelligence tests on certain school students.

S. SINHA, Calcutta.

The writer of the paper carried out the work on some high school students under the Calcutta University. Attempt has been made to construct questions for tests in the Bengali language and to standardize the same under different age groups of both the sexes. In general, it has been found that the girls are a bit inferior to the boys in intelligence. This finding is a tentative one as the tests have not been carried out in a sufficient number of cases. A peculiarity is marked at the age group of 15 years, where it was found that the girls are not inferior to the boys in intelligence. The writer advocates the necessity of stressing the reading of books outside the curriculum.

### 14. A study of writing ability of school boys in Bengal.

H. C. BANERJI, Dacca.

Boys' handwriting shows great individual differences both in quality and speed. So training in schools should be adjusted to individual dif-

ferences and needs. The use of handwriting scales has shown that the high degrees of quality at the expense of speed are not to be insisted on in schools, but regular short practices in speed writing should be given when boys have reached the minimum standard for quality.

An experiment was made at Dacca for the measurement of the speed of writing of boys of different classes in a high school and the results show that the rate in letters per minute decreases but variability increases with the increase in time given for writing from one minute to two minutes and from two minutes to four minutes.

## 15. A study of the handwriting of children in school.

(MISS) R. GHOSH, Calcutta.

Importance of handwriting as a school subject is pointed out. The present study begins with application of tests of handwriting to different groups of children, the grouping being done according to forms and ages.

The actual experiment was performed with girls of the Gokhale Memorial School in Calcutta. Handwritings can be classified as good, average and bad, according to models adopted as norms for different groups. A comparison is made between the handwriting ability of different groups and of individual pupils. The various educational uses of handwriting tests are pointed out. The paper concludes with reference to certain factors that affect handwriting ability.

## 16. An experimental study of errors in reasoning.

D. RAMAKRISHNIAH, Mysore.

In this investigation errors in reasoning due to predispositions and sentiments were studied experimentally by means of tests in reasoning. The tests consisted of syllogisms involving emotional bias and retentive bias, the bias being either in favour of acceptance or of rejection of a suggested conclusion.

Example of an emotional bias for the acceptance of the suggested conclusion :--

Many students are pretty.
*Some girls are students.*
∴ *Some girls are pretty.*

The tests were administered to two groups of University students : (i) students of Logic ; (ii) students who had not studied Logic.

It has been found that both Logic and non-Logic students yield to the suggestion, whether the suggested conclusion is logically valid or not. 81% of the responses of the non-Logic students are affected by their sentiments and prejudices in drawing syllogistic inferences, while only about 38% of the responses of Logic students are similarly affected. Further, it has been noted that for non-Logic students errors created by predisposition are greater than errors caused by emotional prejudices (85% versus 77%) ; whereas for Logic students there is not much difference as between emotional and non-emotional prejudices.

## 17. Experiments in the teaching of oral expression in English

K. D. GHOSH, Calcutta.

The paper deals with certain experiments in developing oral expression in English that were conducted by the writer in classes VI, VII, VIII and IX of the Ballygunj Demonstration School for about a period of two years. They are carefully graded in difficulty and calculated to develop simplicity, clarity, accuracy and facility in oral expression. They are to a certain extent modelled on experiments successfully carried out in

a few progressive institutions in England, Australia, and France. The results obtained at Ballygunj were very satisfactory. The paper describes at length the procedure in connection with each of the experiments.

### 18. Child psychology and behaviour.

U. S. GHEBA, New Delhi.

Behaviour is the product of heredity and environment, both objective and subjective. Unhealthy environment is responsible for infant mortality, diseases of children and misbehaviour. The causal connections in mental life become clear from the relation of Mind and Body as expounded in Dr. G. Bose's new theory of mental life. It is necessary to study behaviour development from birth to maturity.

The child's behaviour may be profitably studied from the standpoint of gestalt psychology in terms of (i) behaviour-patterns, or from the standpoint of analytic psychology in terms of (ii) extroversion and introversion, or again from the standpoint of psychoanalysis in terms of (iii) oral and genital fixations.

## Psychiatry and Psychoanalysis

### 19. A case of 'strephosymbolia' (word-blindness).

OWEN BERKELEY-HILL, Ranchi.

History of case. Views of S. T. Orton, who coined the term 'strephosymbolia', to the effect that this disability is due to a failure in the establishment of complete dominance in one or other cerebral hemisphere. Criticism of 'dominance' theory. Views of James Hinshelwood who looked for an analogy between acquired and congenital dyslexia. Observations of Lucy G. Fildes and her criticisms of Hinshelwood's view. Study of dyslexia by Marion Monroe who has formulated a 'reading index'. Practical value of her opinion that approximately twelve per cent. of the general population have reading disabilities of some sort.

### 20. Some ætiological factors in the pathology of stammering.

I. LATIF, Lahore.

The object of this paper is to attempt an analysis of a few ætiological factors in the onset and cure of stammering by presenting two sample cases from our clinical investigations. These cases by no means exhaust all the possible causes of stammering. Nevertheless, each one of them is sufficiently unique in character to illustrate that the causes of stammering vary enormously from one case to another. A mass treatment of the pathology of stammering is, therefore, inadequate.

### 21. Dream character of religious sexual abstinence.

S. L. SARKAR, Calcutta.

Connotation of the term 'religious sexual abstinence'. It is not merely an acceptance of Hindu convention. The element of religious experience brings about profound psychological changes. There are two classes of dreams. One class is meant for giving relief to the damned up libido. Another class of dreams appears to give a training to the unconscious to avoid sexual imageries and thoughts and thus to maintain sexual abstinence. Some peculiarities in the structure of the latter class of dreams are pointed out.

## 22. Psychic disorder as a phase in the life of certain mystics.

N. N. SENGUPTA, Lucknow.

The doctrinal literatures of *Vaishnavism*, *Shaivism* and of *Tantrik* cults sometimes refer to a condition of psychic disorder which is said to appear in the course of mystic life. The disorders seem to belong to four types: (1) Mainly psychic disorders characterized by illusory perceptions and delusions, (ii) Physical changes usually associated with emotional states, (iii) Certain asthenic changes, (iv) Certain exaggerated motor phenomena. All these symptoms are usually of a temporary nature.

The symptoms of disorder seem to serve certain definite purposes in the economy of mystic life: (i) they break up old habit-patterns, (ii) they serve to break the contact between the mind of the individual and the objects of the environment. In both of these ways, the process of imbalance makes introversion, which seems to be an essential step to mystic life, easy.

It is possible to understand the general scheme of psycho-physical processes that bring about these states of disorder. (i) On the one side, the break with the external world leads to a new arrangement of mental functions. The psychic disorder appears in the period of transition between the break and the reorganization. (ii) On the other side, the release from the strain of adaptation implies emotion. It also implies a change in the organic condition. These influence the *thalamus* which in its turn influences the general course of consciousness. (iii) Again, it is held by Bianchi that most of the organic changes have their representation in the *cerebral mantle*, especially the *sigmoid gyrus*. The change in the condition of this region by the altered working of the circulatory, respiratory and the sexual systems may explain the occurrence of various physical symptoms noted above. It may also account for a general change in the character of mental states with respect to their order and intensity.

## 23. Concept of time.

S. C. LAHA, Calcutta.

(Communicated through G. Bose.)

Time sense is variable. It expands and contracts. In animals, primitive people and children, it is undeveloped. The causes of time-sense have been incorrectly ascribed to perception of events and memory-pictures; but as a matter of fact it is primary and is quite independent of them. It is stretched in pathological anxiety and contracted in Schizophrenia and depression. It depends on the capacity of the libido to attach itself to external objects. It appears in a crude form whenever there is an actual danger to narcissistic libido; but in civilized man it is mainly the result of conflict and appears whenever there is a resistance to the free flow of the unconscious libido. A highly developed time-sense is an artificial product of civilization and is not inherent in our psyche.

## 24. Psychology of fetishism.

M. Z. ABDIN, Bhagalpore.

Psychologists are not agreed as to the origin of fetish. Fetish plays an important part in sex-relationships of human beings both normal and abnormal.

Freud regards fetish as a penis substitute; his contention, that all fetish objects most frequently met with, such as shoes, stockings and underwears, are penis symbols, is not convincing, because shoes and stockings are more appropriately symbols of vagina, being receptacles. It cannot be said that breast and buttocks are penis substitutes. The views of Stekel and others are equally unsatisfactory. But all are agreed that the origin of fetish lies in childhood experiences.

The view advanced in this paper is that the origin of fetish lies in the baby's experiences at the breast of the mother. All fetish objects are substitutes for mother's breasts. It is for this reason that round and smooth objects form the commonest objects of fetish. This view is quite in line with the psycho-analytical standpoint that the breast of the mother is the first object of love and its substitutes, therefore, are subjective excitants of love, by sight or contact.

25. Unconscious factor in skin-colour preference.

D. DATTA, Calcutta.

(Communicated through H. P. Maiti.)

In this short paper certain tendencies in skin-colour preference have been noted and an attempt has been made to interpret them by the mechanism of repression.

26. The Oedipus wish in Hindu icons.

RANGIN HALDER, Patna.

Hindu icons offer important corroborative materials in support of Dr. G. Bose's theory of the genesis and adjustment of the Oedipus wish. Thus the *Sadyōjāta* (*Umā Śivajananī*) the *Mahiṣāsuramardinī*, the head-and-hair-offering images and the *Arddhanārīśvara* images are considered to represent respectively the passive rôle of the child, the ego-identity stage, the castration wish and the active homosexual attitude towards the father. A new theory about the origin of *Linga* worship as a perfect symbol for the Oedipus wish is formulated. The solitary *Linga* stands for the castrated *membrum virile* of the father image. The worship of the *Linga* helps the son to identify himself with it and the *Yoni* motif which comes later serves to satisfy the Oedipus incest wish the culmination of which is to be found in the *Mahāmāyā* image.

## Social Psychology

27. Psychological basis of earthquake rumours.

JAMUNA PROSAD, Patna.

The great Indian earthquake of January 15th, 1934, was closely followed by a period of panic in which a large number of rumours arose quickly and spread widely. Two classes of these rumours, viz., explanatory and astrological, are discussed in the light of psycho-analysis. The explanatory rumours ascribe the earthquake to sin as its cause; and the astrological rumours prophesy further disasters as punishment for sins. The main themes of rumours are therefore the sin and punishment phantasies. Since empirical and rational considerations did not justify the wild rumours, they must be held to be creations of neurotic insecurity and anxiety set up by the catastrophic experience of the earthquake. The anxiety may be traced to the conflict between the regressive desire for life in accordance with the vegetative and animal tendencies, and life in accordance with the developmental impulse towards the attainment of the ideal of self-dependent individuality.

The facts of transmission of rumours and participation in them are social phenomena, not reducible to the effects of common complexes in all cases. They imply the quest for a social solidarity through which an intra-mental security is established in order to counterbalance the internal and ever-present insecurity and anxiety caused by the constant and usually unconscious internal clash between instinct and ideal.

28. Juvenile delinquency—a study.

J. M. Sen, Krishnagar.

The writer of the paper had studied the problem of juvenile delinquency in Calcutta in some of its aspects No less than 10,222 cases were examined. Contributory causes were examined and although several factors were simultaneously present in many cases the following groupings were made: —(*a*) defective discipline, specific instincts, general emotional instability and morbid emotional conditions; (*b*) a family history of intellectual weakness, defective family relationships, a family history of temperamental disorder or of insanity or the like, a family history of physical weakness, poverty and its concomitants; (*c*) intellectual disabilities, detrimental interests together with a lack of up-lifting pursuits and developmental conditions such as adolescence or precocity in growth; (*d*) physical infirmity or weakness in the offender himself.

Detailed information regarding the boys sent to the Reformatory and Industrial schools at Alipore for the years 1935 and 1936 has been given in the paper; history of typical cases while at the Reformatory and Industrial schools has also been furnished.

29. Dreams of the Garos.

T. C. Sinha, Shusung.

The paper records the different types of dreams of the Garos and the interpretations put forward by them. An attempt has been made to find out the laws which govern the interpretation.

30. Certain factors in sex preference.

D. Agarwalla, H. Roy, *and* A. Bisi.

(Communicated through M. N. Banerji.)

The paper is based on a questionnaire study of the attraction of males for females of different ages and for different parts of the female body. Certain definite tendencies have been indicated.

## Hindu Psychology

31. A study of the psychophysical aspect of prāṇāyāma.

Raj Narain, Lucknow.

(Communicated through N. N. Sen Gupta.)

Prāṇāyāma or voluntary control and regulation of breath has been a constant feature of Indian mystic life and discipline. In the Vedas prāṇāyāma appears as an element of ritual. Some of the later Upanisads treat it as an adjunct to spiritual culture. Patanjali regarded it as one of the eight aids to yoga. In *Hatha* and *Kundalini* yoga it assumes a far greater significance in the disciplinary scheme. In the *Svarodaya-sāstra* it flowers into an exclusive method of spiritual advancement. Buddhist mysticism also incorporates regulation of breath as an ingredient of mystic culture. Jaina yoga alone recognizes the spiritual value of prāṇāyāma in a half-hearted fashion.

Prāṇāyāma has been claimed to produce varied results. Some of these results are obviously of a magical nature; these fall outside the scope of our enquiry. Others, however, possess a psychophysical value. The paper attempts to understand and explain the process by which the psychophysical results of prāṇāyāma are produced, and the bearing of these results on the development of mystic life and consciousness.

32. The science of psychic equilibrium.

S. P. ARANYA, Faridpur.

This paper deals with the 'Yoga-Nirvana' cult depicting the method of psychical emancipation from all miseries. It ends by explaining how 'Moksha' of absolute psychic equilibrium is attained by psychological discipline in stages.

33. Principles of Hindu physiological psychology.

M. N. BANERJI, Calcutta.

In this paper have been discussed the Hindu concept of mind, the peculiarities of the sense-organ, and the centres of mental activities. An attempt has been made to interpret the Hindu classification of matter from the psychological standpoint. The Hindu idea that matter and mind are both material has been discussed and the principle of resonance between sense-organs and stimuli has been elaborated. The Samkhya system of Gunas has also been explained and the theory of *Vayu, Pitta* and *Kapha* has been dealt with.

## General Problems

34. Psychological study of language (preliminary communication).

G. BOSE, SAILENDRA KRISHNA LAHA, *and* D. GANGULI, Calcutta

Not much systematic effort has hitherto been made to study language as a whole from the psychological standpoint. The present paper gives an account of the main findings of the writers. It has been found that the human mind, although it acquires abstract concepts from concrete experiences and apparently regards the former as something quite different from the latter, in actual practice converts the abstractions into concrete ideas. The syntax of a language is an index of certain racial characteristics. There is linguistic evidence to show that the European nations are more interested in action than in objects whereas the Indian nations have a preference of objects to actions. Language shows that the human ego exhibits a curious behaviour inasmuch as it tries to deny all changes within itself and makes an effort to project its own experiences into the outer world, itself remaining immaculate. The importance of the different types of libido in shaping linguistic expressions has also been pointed out.

35. The nature of consciousness as immediately observable.

R. M. LOOMBA, Lucknow.

The descriptions of the nature of consciousness as immediately observable as given by James, Wundt, Stout and Ward, as well as McDougall's characterization of mental structure as a conceptual construction are found unsatisfactory. The paper suggests a comprehensive reformulation (i) on the basis of the distinction between immediate consciousness and discriminate cognition recognized in some manner by all these psychologists; the former is (ii) a successive but continuous flow of change of psychoses; (iii) in which fluid constituents including (*a*) substantive parts, (*b*) transitive segments, (*c*) tendencies, (*d*) overtones and fringes, and (*e*) moments of heightened activity or dullness, acceleration or retardation and the like must be recognized with their inherent affinities and spontaneous groupings; (iv) which possesses a feeling of individuality as a whole, (v) without a subject-object antithesis arising; and (vi) to which selective emphasis cannot be attributed. Its

nature determines the character of psychic entities in determinate cognition, which arise by spontaneous use of the mind for adaptation and adjustment. Yet they are conceptual constructions to the extent that abstraction, definition and correlation play a rôle in discriminative attention.

## 36. Criteria of normality.

H. P. MAITI, Calcutta.

The ideas of the Normal and the Abnormal belong primarily to the domain of sociology, for these ideas originate in the course of social interaction of individuals. An examination of the conditions of their arousal indicates the influence of psychological factors. Psychology, on the other hand, begins its work by accepting certain concepts of the normal and the abnormal. After referring to the relation between the two sciences, the paper discusses how far sociology and psychology can agree about the criteria of normality from their respective standpoints. Three concepts of the normal—Social, Naturalistic, and Statistical—are critically examined in this connection. The paper concludes with a few suggestions about 'dynamic' criteria of the normal.

## 37. Examination of 'Intelligence'.

C. E. SPEARMAN, London.

The original and still current theory of ability is based on the concept of 'faculties'. The only other widespread alternative is the comparatively modern theory of 'types'. Both suffer from two fatal defects; one is their extraordinary lack of definite meaning; the other is their failure to fulfil the primary scientific requirement, that of generality. For the most part, the examinations have to contend with many further grave deficiencies; amongst other things, success is apt to depend unduly on the hap of previous experience, on the language employed, and on an obscure mixture of other influences. All these faults can be more or less eliminated by means of the new theory of 'factors'.

Of these by far the most important is the one called by the letter 'G', which enters into all abilities whatever. It is the principal constituent, and only stable one, in all conceptions or measurements of 'intelligence'.

The other chief cognitive factors are those designated as V, M, F, P, O.

To all these constituents of cognitive ability there must be added W, which governs their employment. These seven factors certainly do not exhaust the whole 'personality', or even the whole of what may conceivably be entitled 'intelligence'. But they do go a long way towards doing so. In particular, several of them (including G) admit of valid comparisons between nationalities and races, that speak different languages.

# Proceedings of the Twenty-fifth Indian Science Congress

## PART IV—LATE ABSTRACTS, ERRATA AND ADDENDA, DISCUSSIONS, LIST OF MEMBERS AND INDEX

## CONTENTS

# 1. LATE ABSTRACTS

## *Section I, Mathematics and Physics.*

### 44. The dielectric constants of solid bodies.[1]

C. G. Darwin, Cambridge.

The question of the electric and magnetic fields inside solid bodies is one which seemed to have been settled long ago, but Lorentz's term in $\frac{4\pi}{3}$ P introduces difficulty in the case where the dielectric constant is due to polar molecules, and not merely to the fields induced in atoms. The consequence ought to be that below a certain critical temperature the substance would acquire a permanent electric moment, like a permanent magnet. This effect does exist for a few peculiar substances, but is rare, whereas the old theory suggests that it should be common, and be particularly strong for water. Similar rules should apply for magnetism but the effect would only appear at temperatures of about 0.01°K. Such temperatures have recently been reached, and the substance does not become a permanent magnet at it, but appears to do so at a considerably lower temperature. Thus both for electricity and magnetism the theory needs modification.

The necessary change has been made independently by Onsager and Van Vleck. The idea they introduce is that each molecule is not under the average field, as in Lorentz's theory, but under this field modified by the fact that it is itself disturbing its neighbours. When this is allowed for, it appears that there is certainly no permanent electricity at the critical temperature, and no evidence that it must occur at all. The method is approximative, and is not capable of saying what will happen at these lower temperatures, but it does free us from what seemed a blank disagreement between theory and experiment.

### 99. The values of the atomic constants.

H. R. Robinson, London.

For some years there has been a puzzling discrepancy between the 'oil-drop' and 'X-ray' values of the electronic charge, the two being very nearly in the ratio 136 : 137. This discrepancy now appears to have been satisfactorily explained, and it seems likely that the X-ray value ($4{\cdot}802 \times 10^{-10}$ e.s.u) is correct.

The adoption of this value of $e$ leads, however, to difficulty in interpreting the measurements of certain related constants, and particularly the measurements of the ratio $h/e$. In spite of the attention recently concentrated on the accurate measurement of $e$, $e/m_0$ and $h/e$, and the apparently very considerable improvement in methods, it is evident that the exactness of our knowledge of these constants still leaves a great deal to be desired.

### 100. On units and dimensions.

Sir J. B. Henderson, London.

[1] Published by title only in Part III, Abstracts, page 16.

## 101. Hard cosmic ray showers.

W. Bothe, Heidelberg, Germany.

In the usual shower produced by cosmic rays, the average angle subtended by the tracks of positrons and electrons at the point where the shower is originated is about 20°. The secondary particles forming the shower are completely absorbed by a lead sheet about 2 cm. thick and for this reason these showers may be called soft showers. The properties of the shower of a second kind observed by the present author have been described in the present paper. These showers are much harder than the usual showers and the angle of divergence is below 10°. It is pointed out that the second maximum in the Rossi curve is more pronounced at angles smaller than 10° than at larger angles, and that this can be attributed to the production of tertiary showers by the hard shower. The intensity of the second maximum in the Rossi curve produced by the hard shower is proportional to $Z$ per atom while that in the first maximum due to soft showers is proportional to $Z^2$ per atom. As regards the origin of the hard showers, it has been observed that they are produced by the hard component of the primary cosmic rays.

### *Section V, Botany.*

In connection with Abstract No. 22 of Section V, Botany, page 143 of Part III of the Proceedings of the 25th Indian Science Congress, dealing with 'The structure of the chromosome' Prof. R. Ruggles Gates has sent the following summary of what he actually said at the meeting.

## 22. The structure of the chromosome.

R. Ruggles Gates, London.

This paper discusses particularly (1) the time of splitting of the chromosome and the number of threads it contains, (2) the chromomere *vs.* the chromonema hypothesis, (3) the satellited chromosomes, their relation to the nucleolus and to chromosome phylogeny.

It is pointed out that various appearances have been interpreted as chromomeres when in reality uniform chromonemata were involved. Various errors of observation, technique and interpretation have led to a false appearance of granules on a thread. The hypothesis of chromomeres therefore requires further investigation, especially as regards the supposed relation of chromomeres to 'genes'. Much recent work has shown that the chromosome consists of spiral threads of relatively uniform thickness, the spirals becoming loosest in interphase and tightest in metaphase of mitosis.

The extensive recent work from many laboratories is reviewed, which shows that chromosomes are double structures consisting of two chromonemata variously intertwined in all stages of mitosis, the new split occurring at or about prometaphase. A very large amount of direct observational evidence thus nullifies the idea that chromosomes are single and that the meiotic prophase therefore differs from mitosis in the postponement of the split in the leptotene thread. The leptonema has in fact been clearly observed to be double in a number of cases. Chromosomes have also been shown to be composed of four strands in somatic metaphase and of two intertwined strands in anaphase and telophase. Recent work with Trillium, in which the chromosomes are so large that the details of their structure are far above the limits of resolution, shows that the anaphase chromosomes contain two intertwined chromonemata, while the metaphase chromosomes are composed of four chromonemata

intertwined in pairs. The X-ray experiments bearing on chromosome structure are critically reviewed. It is shown that the evidence is both indirect and conflicting. Each investigator has moreover interpreted his results as supporting the views he already held. This is true of those who hold that the chromosome is (*a*) single, (*b*) double, (*c*) quadruple. It is therefore concluded that the X-ray evidence is too indirect and uncertain to be of value in comparison with the direct observation of structure in the larger chromosomes.

The importance of the satellites in relation to the nucleoli is pointed out, and it is shown how several lines of evidence can be used in a complementary way in tracing the phylogeny of nuclear structure in primary or secondary polyploids: (1) the maximum number of nucleoli in early telophase nuclei, (2) the number of satellited chromosomes and the size of the satellites in somatic and meiotic mitoses, (3) the maximum secondary pairing of bivalents in first and second metaphase. Loss of a satellite in a polyploid has apparently occurred through mutation in various genera. Strains lacking a pair of satellites can arise in this way.

[Paper No. 27 on page 145. Abstract not supplied before is given herewith. The title of the paper is slightly amended.]

## 27. The sexual process in the Rust Fungi.

A. H. R. Buller, Kew.

There are three ways now known in which the sexual process in the Rust Fungi may be initiated: (1) by the fusion of a (+) mycelium with a (−) mycelium, as first observed by Craigie in *Puccinia helianthi* and *P. graminis* and as subsequently confirmed by Brown by means of critical experiments made on *P. helianthi*; (2) by the fusion of a dicaryotic or diploid mycelium (derived from a uredospore) with a haploid mycelium (derived from a basidiospore), as observed by Brown in the autoecious rust, *Puccinia helianthi*; and (3) by the union of a pycnidiospore with a flexuous hypha of opposite sex, as observed by Craigie in *Puccinia helianthi* and recently by the writer in *P. graminis*.

The writer has observed between eighty and one hundred unions between pycnidiospores and flexuous hyphae in *Puccinia graminis*. A union takes place (1) at the end of a flexuous hypha or (2) at the end of a short lateral branch or peg emitted from the side of a flexuous hypha. Not a single fusion between a pycnidiospore and a periphysis (paraphysis) was seen.

The paper was illustrated with lantern slides and models.

# *Section IX, Agriculture.*

## 57. The present state and future development of potato breeding.

Redcliffe N. Salaman, Cambridge.

Potato breeding in England and in Western Europe has reached a stage at which no further improvement is to be expected by the use as parents of any of the existing commercial stocks. This is due to the fact that whilst all objectionable qualities, and with them perhaps much that gave vigour and constitution, have been bred out of the original stocks, and desirable characters such as high cropping, colourless skin, smooth eyes, good shape, good quality, maturing habits and the like, combined with resistance to wart disease, have been retained, there is no further reserve of genic character to draw on. The qualities most to be desired, resistance to blight and virus disease, are missing from all

our stocks. These qualities can now only be obtained by the introduction of new blood from wild species or unrelated cultivated stocks such as may be found in Mexico and South America.

In 1908 the author showed that resistance to blight was controlled by genetic factors and that such resistance occurred in S. edinense and S. demissum. Crosses with S. demissum were begun in 1914 and have been carried on till the present time, using frequent back-crossing and testing each generation for resistance to blight, and economic qualities. The result is that potatoes have been bred which are resistant to the common form of blight, but new strains of *Phytophthora infestans* have appeared, to which they are not resistant. The introduction of still further wild blood has given us potatoes immune to both this and the common blight. There is no reason to hope that before long the task of producing a good economic blight-resisting potato will have been solved.

As regards resistance to virus, there is some hope that resistance to some of the diseases may be obtained from such wild species as S. Ribini. Even, if this resistance is genetic in character there still remains, the task of carrying it over to our economic varieties, which may be difficult without bringing with it the many undesirable qualities peculiar to S. Ribini.

The author is of opinion that valuable progress may be made by protective inoculation methods by which non-virulent virus strains are used as vaccines to protect susceptible plants against infection with virulent strains. This method has shown considerable promise in the laboratory. Inasmuch as such vaccines are naturally carried to the forthcoming tubers, the method allows of a really practical application.

## 58. Hundred ton sugarcane crop.

SETH LALCHAND HIRACHAND, Bombay.

The author showed a cinema film depicting the growing of a hundred ton (per acre) crop of sugarcanes in parts of Bombay. Such crops were raised in response to the announcement of a prize of Rs. 1,000 for a hundred ton (per acre) crop of sugarcane under certain conditions in the matter of maintenance of records, etc. Subsequently a second prize of Rs. 500 was offered for the highest yield of sugar per acre as well. The prize was given, at the instance of Mr. Wallchand Hirachand, by Messrs. Marsland Prize & Co., Ltd., Bombay. Such a heavy crop was rendered possible mainly through four factors, viz., (1) thorough cultivation, (2) heavy manuring, (3) heavy irrigation, and (4) close and careful supervision. Such a crop was obtained from what is known as 'Adsali' crop in the Deccan which stands in the field for eighteen months or a little over.

All needed precautions were taken in the harvesting of the prize plots and estimating available sugar, technical men being told off for the work. Harvests of over 100 tons of canes were recorded from three of the prize plots, the variety being P.O.J. 2878. These results are very striking in view of the general belief at the time of the announcement of the prize that it was almost impossible to raise a hundred ton crop in the areas where the competition took place. The estimated available sugar was, in three cases, over 11 tons (being a little over 11½ tons in two of the plots).

## 59. The rôle of sugarcane crop in the domestic economy of the Punjab cultivator with special reference to the years of economic depression.

KHAN BAHADUR FATEH-UD-DIN, Simla.

Cost of cultivation of sugarcane in the Punjab has been worked out. It is the highest among the provinces. The yields per acre here are far below the rest of India and yet the Punjab has the second largest area

among the provinces. These points led the authors to make a comprehensive study of the statistics of the crop and this has revealed some very interesting facts. A detailed study has been made of the fluctuations in acreage under this crop during the last three decades. The quinquennial averages have been worked out, which for the quinquenniums ending with 1925-26, 1930-31 and 1935-36 have been 427, 737, 415, 983 and 487,088 acres respectively. The quinquennium ending with 1935-36 represents the years of general agricultural depression. A marked increase in area during this period has been of special significance, the reasons for which have been discussed at length. The index numbers of prices have been calculated for wheat, cotton and oilseeds and have been distinctly higher for the latter commodity during the years of agricultural depression. Hence the tendency to put larger area under this crop. The year 1932-33 recorded the maximum acreage since the beginning of this century. The prices during that year were also the lowest that ever prevailed since 1913-14. The effect of acreage on price of gur has also been studied.

About 1.5% of the total area of crops falls under sugarcane, but the crop is far more important than these figures indicate. The gross value of the return per acre is much higher than other money crops. The spare labour with the cultivator—manual as well as bullock—is economically utilized. Taking all these facts into consideration the importance of this crop in the province has been brought out.

The percentage that value of this crop bears to the total value of money crops in the province has been worked out for the different quinquenniums. This percentage during the years of agricultural depression has been distinctly higher than the same for the pre-depression years.

Evidently the crop has played a very important rôle during the days of general depression.

## 2. ERRATA AND ADDENDA

# Proceedings of the Twenty-fifth Indian Science Congress

### CALCUTTA, 1938

### PART III—ABSTRACTS

### (1) *Section of Medical Research.*

[Paper No. 86 on page 256 of Part III of the Proceedings of the Silver Jubilee Session.]

The first paragraph of the abstract should read as follows:—

'It-ching (635–713 A.D.) during his ten-year stay at Nalanda made a successful study of the science of medicine. Translated a medical work 'Bhaishajya Vasthu'. His most famous book is the 'Record of Budhistic Religion as practised in India', in which he devotes many chapters to the rules of hygiene and the principles and practice of medicine in order to satisfy the needs of the time.'

### (2) *Section of Geology.*

[Paper No. 18 on page 113 of Part III of the Proceedings of the Silver Jubilee Session.]

The names of authors of the paper should read:—

18. Tertiary basalts of Bombay Island.

V. S. DUBEY, Benares *and* H. S. DALAL, Bombay.

### (4) *Section of Mathematics and Physics.*

[Paper Nos. 8 and 9 on page 3 of Part III of the Proceedings of the Twenty-fifth Indian Science Congress.]

The names of the authors in the above abstracts should be interchanged as follows:—

8. Diamagnetic susceptibilities and molecular structures.

K. BANERJEE *and* J. BHATTACHARYA, Dacca.

9. Electron map of anthraquinone crystal by Faurier summation method.

K. BANERJEE *and* S. N. SEN GUPTA, Dacca.

## 3. DISCUSSIONS

### I. THEORETICAL STATISTICS.

*(Section of Mathematics and Physics, in co-operation with the Indian Statistical Conference.)*

[No report of the discussions has been received.]

### II. RECENT ADVANCES IN THE STRUCTURE OF ALKALOIDS.

*(Section of Chemistry, in co-operation with the Indian Chemical Society.)*

1. DR. J. N. RAY, Lahore.

   *Recent methods used in the determination of the alkaloids.*

2. PROF. K. GANAPATHI, Bangalore.

   *The structure of the strychnos alkaloids and the biogenesis of the alkaloids.*

3. DR. R. H. SIDDIQI, Aligarh.

   *The molecular structure of strychnine and brucine.*

4. DR. S. SIDDIQUI, Delhi.

[No report of the discussions has been received.]

### III. CHEMISTRY AND INDUSTRIAL DEVELOPMENT IN INDIA.

*(Section of Chemistry, in co-operation with the Indian Chemical Society, and the Society of Biological Chemists, India.)*

1. DR. T. S. WHEELER, Bombay.

Chemistry plays a preponderating part in the application of science to the development of natural resources. In order that it may fill its role in this country it is essential that there should be a regular supply of well-trained industrial chemists. It is necessary therefore that the Universities should provide courses in technical chemistry based on an adequate foundation of pure chemistry, and giving if possible opportunities for specialization in one or two major industries. The development of Departments of Applied Chemistry is expensive and it is essential that Universities should combine to prevent overlapping; all should have the equipment for general training and provision for specialized training in one major industry not covered elsewhere.

The Universities can also help by basing their research programmes on the problems of local industries and their technical chemical staffs should be encouraged to keep in direct touch with these industries. Besides promoting the development of local resources such co-operation will facilitate the provision of posts for University students.

Close co-operation is also advisable between the Technical Departments of Universities and the local Departments of Industries; the latter can supply much valuable information regarding the industrial needs of the Province and the manner in which applied Science can help in solving local problems.

2. Drs. R. B. Forster *and* K. Venkataraman, Bombay.

*Chemistry and Industry.*

Chemistry has played the dominant part in the development of the textile industry in recent years. The complete elucidation of the structure of cellulose and of the constituents of silk and wool has given the processer a knowledge of the nature of his raw materials, which has enabled him to achieve a closer approach to his ideal of producing a desired result in feel and appearance without prejudice to fibre strength. Regenerated cellulose and a variety of other synthetic fibres, individually and in admixture with the natural fibres, have opened up a new range of attractive fabrics. Following Bohn's discovery of indanthrene blue in 1901, the dyer has now at his disposal dyes of a degree of fastness not only hitherto unsurpassed, but representing a permanence greater than that of the fibres themselves. All the colours of the spectrum are available, including the greens; and simplification of the methods of application in dyeing and printing has also become possible. Chief among the advances in dyestuff synthesis are the indanthrenes, the Naphthol AS series discovered by the Griesheim Elektron, the stabilized diazo salts, the solubilized vat colors, the Neolans (water soluble mordant azo dyes containing co-ordinated metal), colloidalized dyes for acetate silk and the Rapid Fasts and Rapidogens for printing. The fastness to washing of dyeings with substantive colours is improved by after-treatment with certain quaternary ammonium salts and allied substances (Fixanol, Sapamine, Solidogen). Scouring, dyeing and other processes have been facilitated by numerous 'auxiliaries', polar substances of more or less complex character, belonging to the aliphatic, aromatic, hydroaromatic and heterocyclic series and possessing one or more of the properties of wetting, emulsification, detergency, dispersion of calcium soaps, promotion of level dyeing, softening of textiles and the ability to impart a special feel or handle to fabrics. The chemical aspects of finishing have become more important than the physical processes of mangling, stentering and calendering. Some examples of such chemical finishing of cotton fabrics are the partial or surface solution of cellulose (superficial rayonization), proofing against damage and deterioration of various kinds (water, mildew, moths, heat, fire), immunization and animalization, and 'anticreasing' by the incorporation of synthetic resins. Lastly, chemistry has not left untouched even the machinery side of the industry; stainless steel and composition materials are being increasingly employed in the construction of dyeing equipment.

The Indian textile industry has so far been content to derive at second hand the benefits of this many-sided progress, and has done little or nothing to make similar advances on its own account. The institution by the University of Bombay of a department of textile chemistry is a first step to bring the largest Indian industry into live contact with chemistry and chemists. The need for rigorous scientific control of processes and for the local production of the chemicals and auxiliaries consumed by the cotton industry is receiving recognition.

Dr. R. B. Forster, Bombay, said:—

Although the dyestuff industry is probably the most complicated industry in existence, it requires very few starting products and the plant involved is comparatively simple.

By the distillation of coal tar over 200 products have been isolated. Out of these only a few are of importance in dyestuff manufacture, namely, Benzene, Toluene, Naphthalene and Anthracene and to a lesser extent Phenol, the Cresoles Xylene, Carbazol. The establishment of a tar distillation plant would therefore lay the foundation stone of the manufacture of dyestuffs and in addition would lead to the establishment of a number of other industries such as the preparation of disinfectants, wood preservatives, motor fuels, fine chemicals, pharmaceuticals, photographs, synthetic resins, solvents, synthetic tannins and the like. The tar distillation industry is, however, not essential as sufficient benzene can be obtained by stripping coal gas and naphthalene is easily imported and with these two raw products a very large number of dyes may be manufactured.

The heavy chemicals, namely, concentrated sulphuric acid, nitric acid and hydrochloric acid are already made in India and several factories for the manufacture of sodium hydroxide and sodium carbonate are in the course of erection. If any of these operate on the electrolytic system, a cheap supply of chlorine should also be available. Provision would have to be made for the production of oleum as many of the sulphonations can only be carried out by its use. The preparation of chlorsulphonic acid from oleum is a simple matter, involving only a supply of oleum and hydrochloric acid. The remaining essential chemicals, such as calcium carbonate, lime, iron, acetic acid, acetic anhydride, ethyl and methyl alcohols should present no difficulty.

The principal reactions in dyestuff manufacture are sulphonation, alkyl fusion, nitration, reduction and chlorination for these operations only simple plant is required consisting of sulphonation and nitration pots, autoclaves and reduction vessels together with aucilliary plant such as filter presses, pumps, nontjus and wooden vats. In connection with the latter, India possesses a great advantage over other countries in as much as she possesses an unlimited supply of teak wood, one of the finest woods for the manufacture of chemical plant.

In the initial stages it would be advisable to import the plant required, but as the industry developed it should be possible to fabricate in India a number of the items which require cast iron, mild steel or copper for their construction. Incidentally this would produce another outlet for the iron foundries and engineering firms.

Apart from its influence on other industries, the dyestuff industry is of enormous importance from a national point of view. What would happen for example if the supply of dyes was cut off or restricted. There is an enormous amount of capital invested in the mill industry and not only would the share holders go dividendless but numbers of work people would be thrown out of employment.

An industry of the nature could not be built up in a day and in the initial stages many of the external products would probably have to be obtained from outside sources. In the case of a dye like Congo Red it is possible to start with Benzidine and Naphthionic acid gradually work backwards—when in due course the starting points would be Benzene and Naphthalene. After all half a loaf is better than no bread.

3. Dr. B. C. Guha, Calcutta.

*Development of chemical industry in India.*

During recent years throughout the world there has been increasing co-operation between pure science and applied science. Not that the distinction was ever water-tight, but of late the conscious application of science to human and social benefit has been greatly stimulated. This

need is all the greater in this country, where industry is still in its infancy. So far as chemistry is concerned, the situation is not very much better, many of the basic chemical industries being absent while most of the others largely concerned with drugs have to depend on imported chemicals. Coal is an example, where nothing is derived except coke, tar and coal gas, all other valuable bye-products being wasted.

For the starting of many chemical industries, talents inside in the country are available. Raw materials and sources of power are also available. Experience shows that many machineries can be made according to design inside the country. But it has been felt that the requisite contact between scientists on the one hand and industrialists on the other has been lacking. I beg to suggest that organizations may be set up, which would represent (1) University Science departments, (2) the Industries Departments of the Central and Provincial Governments, and (3) the Chambers of Commerce. Establishment of such contacts would, I think, help to infuse a greater sense of reality into the work of the University Science Departments and make them more responsive to industrial needs. Industrialists would at the same time realize what help science is capable of rendering to industry. This may reasonably be expected to lead to the establishment of new industries and expansion of the old.

So far as Applied Chemistry teaching in the University is concerned, it is suggested that there should be greater co-ordination among the different Universities. While each centre should give instructions in the fundamentals of chemical technology, it is desirable that a centre should specialize only in particular directions, depending on its peculiar environments and local industrial possibilities.

4. DR. H. K. SEN, Ranchi.

*Lac research in India.*

DR. H. K. SEN, Director, Indian Lac Research Institute touched upon three points :—

The training in the Universities is not being fully useful as the students do not have a truly machine sense. The latter can be developed by beginning such training in its elements from the age of 4 or 5 in the schools. Carpentry, gardening, visits to museums, etc. Machine drawing is the language of the technical man, and the imagination of the student must be properly developed to get an efficient technical staff. The Universities of the country should, therefore, examine this question and create such changes in the elementary school curricula that would help to develop this machine sense.

He then mentioned the need for investigating the fuel and the fibre problems. We have a small coal deposits and any method of economy in this industry would be of vital national economy. He specially referred to low temperature carbonization of Indian coals which he thought would introduce real economy in the fuel industry on the one hand, and would simultaneously yield the tar as a proper raw material for various chemical industries. Incidentally he mentioned a simple plant which he and his colleagues had developed during the last six years in the University of Calcutta, which could provide all Universities and technical establishments with gas at practically no cost, and furnishing the tar for examination by a body of research workers whose wages would be found from the economy in the cost of gas production itself.

The fibre industry which is of equally great importance deserves similar attention. The cane sugar industry has brought within reach a fibre the value of which remains as yet unutilized. For building materials such and other fibres should be intensively investigated.

In the end, Dr. Sen deplored the want of proper co-operation between the technical man and the capitalist, which, to his mind, is the real

reason for the absence of big industries. Initiative and enterprise, and more than all, the combination of the capitalist and the technical man would create a different phase in the future of Indian industry.

5. Drs. H. B. Dunnicliff, Gilbert J. Fowler, V. Subramanyan, K. Venkataraman, K. G. Naik, M. S. Patel, K. L. Mudgill *and* Miss Ram, took part in the discussion.

6. Sir Henry Tizard.

Sir Henry Tizard suggested the appointment of research boards by the Indian Science Congress.

## IV. PRE-CAMBRIAN SEDIMENTATION.

*(Section of Geology.)*

1. Mr. B. Rama Rao, Bangalore.

Including under the comprehensive term Pre-Cambrian all the rock formations anterior to the great eparchean interval, the main features of sedimentation of the Archean times as exemplified in the Dharwar rocks of Southern India are dealt with. The process of sedimentation of this extensive era has been considered under three periods.

During the first or the oldest period, there was a dominance of vulcanism with hardly any sedimentation. Such of the few types as could be recognized as possible sediments are of the nature of chemical depositions, mainly siliceous, derived from the decomposition of their closely associated volcanic rocks which in parts at least, seem to have been sub-aqueous. Towards the top of the period, signs of disintegration probably under hot moist conditions, and mechanical sedimentation become apparent, but still the processes of weathering were incomplete and the weathered products were never conveyed far from their sources.

During the second period, specially towards its end, signs of setting up of meteoric conditions akin to those of the present day are better evidenced. Graphitic carbon and graphite are conspicuous in some of the rock types, indicating the probable advent of the original primitive plant life at about this period. There was still considerable amount of chemical deposition,—and this time lime, iron and silica were the products of precipitation. There was also mechanical deposition. The possible sources of material for these sedimentations with reference to environment, the nature of the depositional basins and the conditions of deposition, etc. are briefly touched upon.

The end of the era indicates conditions of sedimentation not very different to what are commonly observable at the present day. The sedimentary material of this period represents the broken down products of the various types of pre-existing rocks ; transported, sorted and deposited like the present day sediments.

2. Dr. M. S. Krishnan, Calcutta.

Most of the sedimentary types in the Pre-Cambrians do not call for special comment. The iron formations and manganiferous rocks are peculiar in that their deposition has not been repeated in later ages to a similar extent or magnitude.

The banded iron-bearing rocks are widely distributed in India—in Orissa, Central Provinces, Bombay, Hyderabad and Mysore. Most of them at any rate are of sedimentary origin, the iron being probably derived from the weathering of pre-existing rocks. Some of the deposits have

been metamorphosed, giving rise to magnetite-schists and magnetite-amphibole-schists. Superficial enrichment has given rise to important deposits of iron-ore of high quality. Other peculiarities of the formations are also discussed.

There are three different groups of manganiferous rocks in India, gondites, kodurites and manganiferous shales. From the original sediments gondites have been formed by metamorphism, while kodurites are products of hybridism between the sediments and igneous rocks. All the three types have given rise to residual ores, but the primary ores associated with the gondites are the most important.

Though iron and manganese occur in close association in rocks and minerals, on going into solution they tend to be segregated during deposition. The abundance of oxygen determines whether carbonates or oxides are to be deposited.

3. PROF. L. RAMA RAO, Bangalore.

In discussing any aspect of Pre-Cambrian geology, the following facts have to be remembered: (i) the Pre-Cambrian strata are of very wide extent, visibly covering nearly one-fifth of the whole land surface forming the shield areas; and even among the other four-fifths of the continents, they probably exist over large areas deeply buried under the later formations; (ii) their total thickness exceeds that of all the rest of the strata put together, and they thus represent a very long period of time—much longer in duration than the whole of the time represented by the Cambrian to the present day; (iii) the Pre-Cambrian beds of any area are not merely a series of deposits laid down one after another throughout the period; on the other hand, the sequence is frequently interrupted by prolonged periods of diastrophism and denudation, giving rise to unconformities which constitute 'the most wide-spread, strongly accentuated and deeply significant structural features' of this part of the geological record, and represent extensive featureless surfaces of peneplanation the like of which it is impossible to see during the later periods; (iv) due to the continual operation of two factors, magmatic absorption from below and denudation from above, it follows that what we now see of the Pre-Cambrian rocks form only a part—probably a very small part—of the entire original formation.

In the study of Pre-Cambrian sedimentation, two questions naturally come up for consideration: (*a*) what was the appearance of the face of the earth at the beginning of geological history?—was there a world sea encompassing the whole earth or were there, as now, continental blocks and sundering oceans? (*b*) was the composition and character of the primeval oceans and of the atmosphere under which they lay, the same as it is now? and were the processes of sedimentation—mechanical, chemical, and organic—similar to those of the present day?

In connection with Pre-Cambrian sedimentation, there is another important problem to discuss, viz., what part, if any, did life play in the building up of these ancient rocks. It is true that, of undoubted organic remains, there are very few indeed; and even these are mostly found only in the later Pre-Cambrian sediments. But yet, taking into account all considerations, there seems to be no doubt that many more forms of life flourished in the Pre-Cambrian seas than the actual fossil record indicates. Absence of fossils need not necessarily mean absence of life, particularly so in the case of so remote a period as the Pre-Cambrian. The Pre-Cambrian seas must have been teeming with life of a kind which could never be preserved in the fossil condition, but nevertheless played an important part in determining the course of contemporary sedimentation.

4. PROF. P. G. H. BOSWELL, F.R.S., London.

In connexion with the discussion on Pre-Cambrian sedimentation, Professor Boswell commented on the fact that in calcareous sediments

of much later date, e.g. Chalk and the Recent limy muds of the Bahamas, no trace often remained of the organisms which had played a great part in the formation of the deposits. It was possible, therefore, that organisms such as bacteria and algæ might have played an important part, even if an indirect one, in the chemical processes of Pre-Cambrian limestone formation. And the same might be urged, for some occurrences at least, of the banded iron ores.

The problem of Pre-Cambrian graphites associated with limestones was also of much interest. Now that so many rare elements were found by spectroscopic tests to be characteristically present in coal-ash (e.g. germanium, vanadium, etc.) and our knowledge of their occurrence in animals was increasing, a spectrographic study of graphite associated respectively with limestones and igneous rocks seemed to be called for. Light might be thrown on the mode of origin of limestone graphite—whether organic or inorganic, and if organic, whether plant or animal—by such 'blood tests'.

5. DR. C. MAHADEVAN *and* MR. SYED KAZIM, Hyderabad (Deccan).

*Pre-Cambrian sedimentation in the Bhima-Kistna basin.*

A series of sedimentary rocks consisting of conglomerates, sandstones, shales and limestones occupy roughly an area of about 2,000 square miles in the Bhima-Kistna basin. Their maximum thickness is computed to be less than 800′. Bruce Foote and King, two of the great pioneers of Indian Geology who surveyed this part of India about 70 years ago, gave them the name of 'Bhima Series' and relegated these formations, on lithological grounds, to the Kurnul Series of the Purana Group of Sir Thomas Holland. In the entire absence of fossils and stratigraphic evidence to assign their horizon with certainty, lithological considerations are the main criteria to fix their age. (Mem. G.S.I., Vol. XII, pp. 139 to 164).

During the recent survey of the Gulberga district by the Hyderabad Geological Survey, some observations of interest were recorded which are briefly reviewed here.

Bruce Foote divided the Bhima Series into two stages, a lower stage consisting of conglomerates, sandstones and shales, and an upper stage, of limestones, sandstones (local) and shales. The recent detailed study, however, brings out the fact that three distinct stages are recognizable in these sedimentary formations.

In the first or lowermost stage conglomerates and sandstones are succeeded by dull green, purple and red shales. Their total thickness is not over 200′.

In the next or middle stage limestones of cream, blue, black and buff colours were deposited. These have a maximum thickness of about 250′. Field evidence clearly suggests that during this stage the Bhima sea must have attained its maximum extent when dry land adjacent to the original sea underwent submergence. We therefore find that limestones sometimes directly overlie the Peninsular gneisses without the intervening sandstones and shales.

The third or upper stage heralds a period of upheaval. A great part of the area covered by the Bhima sea again became a dry land, mechanical sedimentation taking the place of chemical precipitation, in the area still covered by water. In this last stage, local beds of the sandstones along what seems a shore line, were formed. These are succeeded by buff, black, blue and purple shales. Naturally, oscillation in levels must have taken place during the period of deposition of these beds. The uppermost beds are confined to the northern and western parts of the Bhima basin.

The structural features presented by these formations are comparatively simple. The beds are nearly horizontal and except for

compaction show little evidence of metamorphism. Some faults have been noted, the longest of which is about 50 miles with a run of 30 miles West to East and about 20 miles South to North. This was traced eastwards from Honhalli (Lat. 26° 44′ 55″, Long. 76° 26′ 10″) through Gogi to Makhtapur (Lat. 16° 45′ 30″, Long. 76° 49′ 50″). From here it takes a northerly swerve to Radewadgi (Lat. 17° 40′ Long. 76° 47′ 50″). This is a normal fault with the throw varying from place to place.

A case of reverse faulting noted between Warchanhalli (Lat. 16° 51′ 12″, Long. 76° 48′ 30″) and Jewargi (Lat. 17° 18′, Long. 76° 46′ 20″) brought to light clearly by the data afforded by deep wells recently excavated in the area and by surface observations clearly proves that the Mudbal and Jewargi limestones are not intercalated beds in the Upper Shale stage as suggested by King (Mem. G.S.I., Vol. XII, p. 160). The anomalous position of the shales is seen to be due to faulting. It is surmised that the faulting took place subsequent to the deposition of the sediments. They are definitely pre-trappean in age. The beds dip at moderately high angles all along the fault line.

A feature of peculiar interest in these formations are the local occurrence of large scale slipping-in of beds due to the removal of the underlying layers. At Ladlapur (Lat. 16° 58′ 40″, Long. 77° 2′) a large mass of brecciated limestones is seen lying at the foot of a conical hill composed of shales, obviously displaced from the summit of the hill.

Recently, in the last session of this Congress, a suggestion was put forward that the salinity met with in southern parts of Gulberga district and in the Raichur district is mainly ascribable to concealed saline beds lying below the shales of the Bhima Series. That is to say, there were periods of marine regression and desiccation of parts of the basin, giving rise to saline beds which are supposed to have been overlaid by later sediments of the Bhima Series. This suggestion, i.e. of the alleged presence of concealed saline beds has been very carefully gone into by the Hyderabad Geological Survey during the recent work in the Bhima Series. Thanks to the systematic and extensive excavations of wells in this area by H.E.H. The Nizam's Well Sinking Department for village water supply, we have reliable and complete data on the quality of water available in these sedimentary formations through practically the full extent of the Bhima Series, and along the junctions of gneisses and sandstones, of sandstones and shales, shales and limestones, etc. hundreds of wells have been examined but no case of salinity was met with. A few isolated occurrences of brackish water, such as near Wadi railway station, are obviously due to contamination of surface waters through mantle of thick black cotton, soil, during filtration. We have also incontrovertible evidence that black cotton soil wherever it occurs, for example on gneisses, on Dharwars and Deccan Traps gives rise to sometimes salinity of the subsoil water.

No fossils have been so far met with, though conditions were most favourable for their preservation. Recent writers on sedimentation are inclined to ascribe the black and blue colour of the shales to organic origin. To what extent the black and blue shales of this area owe their colour to this agency will be an open question till some definite evidence of life is proved in these formations.

## V. THE ORIGIN OF BANDED GNEISSES.

*(Section of Geology.)*

1. Dr. M. S. Krishnan, Calcutta.

Three types of banded gneisses have been observed in the Gangpur-Ranchi area of Chota Nagpur, viz., biotite-gneiss, calc-gneiss and amphi-

bolite-gneiss. The lighter bands in all these consist of aplitic or granitic material injected into the rocks in *lit-par-lit* fashion. The darker bands in the biotite-gneiss contain the usual constituents of biotitic schists; in the calc-gneiss the constituents are the calc-silicates actinolite, tremolite, epidote and zoisite; in the amphibolite-gneiss they are hornblende, quartz, clino-zoisite, ilmenite and spheno. The biotite-gneiss is found over a large area near the margin of the granite batholith of Ranchi, the granitization and banding dying away with distance.

The experimental work of Goranson in the Geophysical Laboratory at Washington shows that pegmatite and aplite crystallize within the temperature range of 700°–550°C. and quartz veins at still lower temperatures. A typical granite which contains 1% water, at a depth of 10 km., will give at a temperature of 700°C. a residual liquid which is 15% of the original rock with 6·5% of water in solution. The amount of water held in solution will depend on the pressure to which it is subjected. Hence, granite magmas at a depth of a few kilometres can be expected to give sufficient residual fluids to soak or to penetrate porous and schistose rocks in their neighbourhood and give rise to granitization and banding.

2. MR. B. RAMA RAO, Bangalore.

Banded gneisses have originated under different conditions and several types of such gneisses are recognizable in Mysore. All the various types may be broadly classed under the following three main divisions :—

(1) Banded ortho-gneisses ;
(2) Banded para-gneisses ;
(3) Banded composite gneisses.

In group (1), banding is generally noticeable due to the following conditions :—

(*a*) Flow banding produced at the margins of the later granites.
(*b*) Parallel orientation of coloured minerals in deformed granitic rocks.
(*c*) Incorporations of streaks and stringers of dark hornblende-schists in the granitic rocks producing various types of banding commonly noticeable in the Peninsular gneiss.
(*d*) Acid injections along planes of weakness in the hornblende-schists which have given rise to banded dioritic gneisses, banded hornblende-pyroxene-gneiss and several other types.
(*e*) Intermingling of granitic rocks and norites which have given rise to some banded hypersthene-gneisses.

(2) Crystallization of different layers of original sediments have given rise to certain types of banded gneisses and schists, like the sillimanite-cordierite-gneiss of Channapatna, and the various exposures of kyanite-sillimanite-gneisses of the south-west parts of Mysore.

(3) Certain garnetiferous micaceous gneisses, hornblendic micaceous gneisses, and cordierite-hypersthene-gneisses could be classed under composite banded gneisses, and in many of the outcrops of such rocks banding is seen to be due to lit-par-lit injections of acidic veins, in the original sediments.

3. MR. L. S. KRISHNA MURTHY, DR. C. MAHADEVAN, *and* MR. SYED KAZIM, Hyderabad-Deccan.

Field observations in Raichur and Gulberga districts throw light on the origin of banding in the granitoid gneisses of the Peninsular complex. Some of the salient points of this study will be briefly stated.

Banding in the Peninsular gneisses may conveniently be classed under two main types :—

(1) Banding in the grey series produced by aplitic and pegmatitic phases of the same series and from injections of the pink series.

(2) Banding in both grey and pink series, produced by long runs of basic rocks. These are seen in the contact zone of the schists and gneisses.

4. MR. H. N. GANGULI, Calcutta *and* MR. G. C. CHATTERJI, Dhanbad.

*The Origin of Banded Gneisses of Hazaribagh.*

The rocks involved in the production of the hybrid gneiss in these areas are an older schist or amphibolite and a newer granitic (the present granite-gneiss—'dome gneiss') intrusive with its later pegmatitic phase.

The hybrid gneisses range from banded gneisses with distinct alternating bands of basic and acidic materials through streaky gneisses to homogeneous melanocratic biotite-gneiss.

There are evidences to prove that the pre-existing basic rock was invaded by an acid magma firstly inbroad patches, and thereafter more and more closely in a lit-par-lit manner. In places where penetration was complete homogeneous gneisses resulted.

The basic rock before incorporation in the granitic material was reduced to a plastic state which facilitated the intimate permeation of it by the invading magma. The plasticity is inferred from local fault of basic bands in the banded gneisses and from the ptygmatically folded acid veins in the basic rocks.

The first acid magma to invade the basic rocks was the main acid intrusive of the area. Later pegmatitic and aplitic material invaded the earlier rocks, probably still in the process of consolidation. The idea is corroborated by the occurrences of interstitial microchine in the gneiss and by the occurrence of pegmatitic and aplitic veins and dykes that cut across the banas of the banded gneiss, often sending veinlets along the banding planes of the gneiss. These pegmatites thus to a great extent had been responsible for the banding.

The microscopic evidence of the permeation of a basic rock by an acid one is furnished by (*a*) the intrusive relation of quartz with plagioclase and femic mineral and the formation of diablastic intergrowth; and (*b*) inclusion by the acid magma and its materials of the constituents of the basic rock.

During the earlier stages, i.e. during the period of mechanical shattering, augite was produced from hornblende, in the separated amphibolite bands, and a little quartz was introduced.

With more intimate penetration in the streaky gneiss more augite was produced from hornblende but in the more homogeneous varieties, i.e. where the penetration of the acid magma was completed, biotite is far more prominent than hornblende and augite, with usually a subordinate amount of muscovite.

With the thinning of acid and basic layers further interchange of materials between the invading and the invaded rocks took place, the evidence of which is furnished by the formation of myrmekite, etc. the basic rock was acidified and *vice versa.* Ultimately a uniform rock intermediate in composition between the amphibolites and the granitic rocks was produced.

Myrmekite is generally absent in the homogeneous gneisses due evidently to a more complete reaction between the invading magma and the invaded rock.

Sphene was formed around ilmenite due probably to reaction between the latter and some lime, that might have been available due to the interchange of material between the acid and the basic components of the hybrid gneiss.

5. Prof. H. H. Read, University of Liverpool, England.

In such an individualistic science as Geology, a discussion tends to become a symposium of a number of detached views. Each contributor gives an account of his own personal experiences, and it must be left to a master-mind to correlate and assess the various contributions. Particularly this must be so in a discussion dealing with so complex a subject as the origin of the banded gneisses. The best that we can hope for today, therefore, is to hear the personal views of those geologists present who have had occasion to deal with banded gneisses in the field.

Perhaps I can best begin my own contribution by stating a fact which, though obvious, is often ignored, and that fact is this:—a banded gneiss is a gneiss with bands, i.e. a gneiss with distinct more or less continuous layers of different compositions. I am not concerned with the homogeneous and massive varieties of metamorphic rocks.

The first enquiry that I wish to make is the following. Can dislocation-metamorphism produce banding? The only case known to me of the production of banding by pure dislocation is that of the ribbon-mylonites associated with clean-cut thrusts. Sheared rocks in general are not banded; on the contrary, shearing tends to obliterate banding present in the rock before it was subjected to shearing.

My second point concerns flow-banding in igneous rocks. This banding, apart from some developments in the gabbroic rocks, is restricted in extent,—original 'pure' igneous rocks are not banded. I believe that only a very minor proportion of the banded gneisses owe this character to a flow-banding in an igneous rock.

In my view, *banding in gneisses is inherited from or controlled by originally banded rocks.* Banding is therefore predominantly dependent upon original sedimentary structures. Banding in gneisses arises in two main ways:—

(1) by inheritance from pure sediments
(2) by an injection-process controlled by sedimentary banding.

I now consider these two cases.

(1) Banding may arise by the recrystallization of an originally banded sediment. In this process of recrystallization there is a chance that there may be a partial or complete destruction of the original sedimentary banding by the operation of metamorphic diffusion and metamorphic differentiation. In these two closely related processes, movement of material from one part of the rock to another takes place during the act of metamorphism. It is unwise, in my opinion, to believe that the different layers in a banded gneiss have compositions identical with those of the corresponding layers in the original banded sediment. As a side-line to this topic, I should like to call your attention to two points, namely, the common preservation of banding in rocks of high metamorphic grade and the equally common destruction of banding in rocks of low metamorphic grade. I would put the question as to whether a progression from unaltered banded sediments through rocks of the epizone into rocks of the higher-grade zones is always requisite. I suggest that many high-grade banded gneisses have missed some of the lower stages in their formation.

(2) An equally important process in the production of banded gneisses is that connected with igneous injection. It is becoming increasingly clear that metamorphism on a regional scale is accompanied by the injection of material of magmatic origin, usually granitic in character. This is especially evident, of course, in the rocks of high metamorphic grade. The great injection-complexes of Scandinavia, Scotland, the Alps, the Pyrenees, United States and elsewhere, supply abundant evidence on these points. A very important group of banded gneisses, therefore, is that of the so-called injection-gneisses.

In this connexion, I should like to hasten to express my opinion that we incline to emphasize unduly the importance of the so-called lit-par-lit injection as a cause of banding in injection-rocks. While I agree that late plane injection of 'magmatic' material along planes of weakness,—foliation-planes, fracture and joint planes—does give rise to banded gneisses, still I hold that gneisses arising by such a process are relatively insignificant in the whole body of banded injection-gneisses. In the case of granitic injections, such introduced lits may be recognized by the development of selvages of enlarged biotite or hornblende adjacent to the incoming quartzo-feldspathic layers.

The main process operative in the formation of the injection-gneisses is, I believe, one of replacement or metasomatism. This is no new idea, for it is inherent in the classic work of Michel-Levy and Lacroix on the French complexes, of Clarence Fenner in the United States, of Hugh Miller Junr. in Scotland and of many other observers in divers districts. My own work in the great Sutherland complex in the Northern Highlands of Scotland has shown me that a great deal of the injection-process is carried on not by discrete injection of igneous material but by a permeation of the country-rock by solutions derived from an external source, presumably an igneous reservoir. In the Sutherland complex, we can demonstrate the passage, *along the strike*, of sedimentary rocks of various kinds into injection-gneisses and migmatites. Permeation-gneisses and biotite-rich augen-gneisses arise from pelitic rocks, augen-gneisses from semipelitic rocks and hornblendic augen-gneisses from banded hornblende-granulites. Apart from the microscopic evidence, which is abundant and clear, it is evident from the preservation of the original attitude of the detailed succession of the country-rocks when they are involved in the migmatite zone that we are dealing with a pseudomorph, as it were, of the country-rock in migmatitic material. The preservation of the plane-banded sedimentary attitude in rocks now consisting dominantly of 'granitic' materials points unquestionably to the operation of igneous metasomatism. Country-rocks of different compositions react with the advancing solutions in different ways and to different degrees. The result is the production of a multitude of banded gneisses whose detailed characteristics depend upon their original composition and the stage reached in the metasomatic process at any given place.

To sum up, therefore, banding in gneisses depends fundamentally on a banding, usually sedimentary, in the original rock. This original banding is either preserved by recrystallization or it controls the formation of banded gneiss in injection-complexes, in which differential metasomatism plays a predominant part.

## VI. THE SIGNIFICANCE OF BOUNDARY FAULTS IN THE SUB-HIMALAYAS.

(*Section of Geology.*)

1. MR. P. EVANS, Digboi.

The sub-Himalayan zone of the outer Himalayas in the Simla, Dehra Dun, and Naini Tal region is made up of a long narrow belt of Tertiary (mainly Miocene and Pliocene) rocks. The beds have a general northerly dip, and are separated from the older beds to the north by a thrust-fault. Within this strip it is usual to find the newer beds to the south and the older to the north, the apparent contradiction being explained by the presence of nearly parallel strike faults.

A hypothesis developed by Middlemiss, following up a suggestion of Medlicott, postulates that the main fault to the north, and to a lesser extent the smaller faults within the Tertiary strip, are 'boundary faults' marking very closely the original limits of deposition of the successive

groups. This hypothesis supposes that to a large extent the faults were successive, and not contemporaneous.

This conception of 'boundary faults' is still accepted as the orthodox interpretation of the structure and stratigraphy of the sub-Himalayan zone.

Hayden and Pascoe have applied this hypothesis to the Naga Hills structure in Upper Assam, and have regarded the conditions here as analogous to those in the sub-Himalaya. Suess, Wadia, and others have suggested that the Naga Hills structure represents the continuation of the Himalayan folding beyond the Assam Valley syntaxis, comparing this feature with the Jhelum Valley syntaxis at the other end of the Himalayas. This appears to be a very probable interpretation.

Detailed mapping in Assam has shown that the Disang thrust-fault of the Naga Hills is not a south-eastern limit of deposition as suggested by the boundary fault hypothesis. A rejection of the hypothesis in one area, even if closely related, does not necessarily invalidate its application elsewhere, but it does undoubtedly point to the need for re-examination of the evidence on which the hypothesis is based.

The main argument in support quoted in the Manual of the Geology of India is that 'if the many thousand feet of tertiary strata found south of the fault had been laid down in a continuous sequence previous to its formation, they must have extended far to the north of it, and it is almost impossible to understand how they could have been so completely removed as to leave no trace of an outlier' but this does not appear to accord either with modern ideas of the degree of denudation of the Himalayas, or with the results of recent mapping near Simla and elsewhere, and the object of the discussion is to consider the evidence for and against the accepted interpretation of the boundary faults.

The rival conceptions may be summarized :—

(*a*) the faults are mainly successive (that is, were formed at the end of the period during which the sediments immediately to the south were deposited) and mark approximately the limits of deposition of successive beds.

(*b*) the faults are in the main of post-Miocene age, largely contemporaneous, and have no close connection with the limits of deposition of the Eocene and Miocene beds.

It seems impossible to obtain any clear picture of the mechanism of the Himalayan mountain building movements until such a fundamental contradiction is resolved.

2. Mr. D. N. Wadia, Calcutta.

Geotectonic work in the Punjab Sub-Himalayas has helped to define the real boundary of the Himalayas, i.e. the limit of the geosynclinal deposits against the epicontinental and fluviatile deposits laid down on the marginal foreland and which have been involved in the later subsidiary phases of upheavals. This boundary is a well defined thrust-plane or zone of thrusts bringing the Himalayan Palæozoic to Eocene rocks into juxtaposition with the Miocene and later Piedmont deposits (Murree and Siwalik). The term 'main boundary fault' applied to this fault is clearly a misnomer.

South of this thrust-plane there are a system of more or less parallel reversed faults of remarkable persistence from east of the Jhelum in Punjab to beyond the Ganges. These may be the true boundary faults, i.e., limits of deposition of successive zones of Upper Tertiary strata as much as tectonic dislocations, possessing the characteristics, structural as well as stratigraphical, ascribed by Medlicott and Middlemiss to these remarkable lines of demarcation in the Sub-Himalayan Tertiaries. These 'boundary' faults are highly characteristic and constant features of the Punjab, Kumaon, and Garhwal Siwaliks, exhibiting the relationship commonly ascribed to them, viz., that each zone, as it follows the next

one, contains a younger Siwalik stage as its oldest rock-group. It is only at the western and eastern ends of the main Himalayan arc that the characteristics of the boundary faults change and that they cease to be original limits of deposition marking the southwardly advancing foot of the Himalayas at the successive uplifts.

The remarkable observations made by Mr. P. Evans in the Assam ranges show the absence of typical boundary faults at this end of the arc. Similarly in the Kashmir foot-hills at the west extremity these parallel lines of faults are observed to die out and to be replaced by simple fold-axes, or normal faults, which do not possess any significance as boundary faults or limits of deposition.

The old conception that the faults mark cliff-faces of the southern front of the Himalayas, against which piles of sub-montane sediments were laid down could only be true in a very limited and general sense at the most typical localities.

Tectonically these faults-cum-limits of deposition should be regarded as having been caused by the sagging of the north rim of the foreland at successive epochs of uplift of the Himalayas to form the complementary Gangetic depression at their foot. The sinking of the Indo-Gangetic trough must have been in stages, probably correlated to the orogenic pulsations, each stage marked by a fault-plane, giving rise at the surface to the features associated with boundary faults.

3. Mr. J. B. Auden, Calcutta.

Mr. J. B. Auden began by describing the work of Medlicott and Middlemiss in connection with boundary faults, and then discussed their conclusions in the light of evidence collected during recent surveys. Certain boundaries, which were thought to mark the limits of present distribution of rock groups, were considered by Medlicott to have been topographical features which originally determined the limits of deposition. This idea implies that those strata which are now absent from regions of elevation were never deposited there. These views have been found to be untenable with regard to the Nummulitic and Dagshai beds, which crop out further north within the lower Himalaya than was formerly supposed, frequently occurring as inliers below thrust sheets. There can be no question of such boundaries with the overlying thrust sheets being original topographical features. L. M. Davies has recently suggested that the Upper Ranikot sea extended from near Lhasa to Bagdad. Even accepting the original premises of Medlicott and Middlemiss, two of the so-called boundary faults of Hazara do not warrant their designation as such.

Medlicott was unwilling to admit of anything more than local and unimportant movements along the margins of his supposed elevations. Middlemiss and later workers have realized that great faulting must have occurred. More recently there has developed the conception that these faults are in the main thrusts, and that the movements along them had a considerable horizontal component.

The idea of faults developing and moulding topography in such a way that deposition becomes limited to the downthrow side is no longer a valid explanation of the position of the older Tertiaries occurring below the major overthrusts within the Himalaya. The great overthrusts were probably just post-Murree, and it was probably not until these had formed, and the tectonic units thus piled on each other had begun to rise as a mountain chain, that the geography of northern India began seriously to be modified. Once the mountainous region had formed it may be supposed that there were effective limits to the deposition of the young orogenic sediments (Siwaliks) both in the north, in Hundes and the northern slopes of the Kun Lun, and in the south, along the southern flank of the Himalaya. In as much, however, as the faults marking the present surface limits of these late Tertiary rocks are inclined thrust planes, it follows that the actual limits of deposition must lie northwards, below the overthrust units.

4. Prof. P. G. H. Boswell, London.

Professor P. G. H. Boswell found himself in the position of the passing Irishman who asked 'whether this was a private fight or might anyone join in'. As an outsider he (the speaker) with the humility born of ignorance failed to understand the raison d'être for the discussion. He could not recall a similar discussion on the question as to whether a boundary fault divided off the Alpine or Carpathian mountain masses from the adjoining basins of deposition. There were, of course, 'boundary faults', but they changed in position in successive phases of Alpine mountain-building, with the result that later movements caught up and included within the main mountain-mass sediments derived from erosion during earlier phases of uplift. He gathered that Tertiary sediments were similarly found on the Himalayan side of the boundary faults.

## VII. THE TEACHING OF GEOGRAPHY IN INDIA.

*(Section of Geography and Geodesy.)*

Dr. Chatterjee in his opening speech said that Geography was the most neglected subject at present in India. In support of this he pointed out that of the hundreds of colleges affiliated to the 18 universities only five or six colleges teach Geography in B.A. or B.Sc. course and only one provides facilities for the study of this subject in the M.A. course; whereas it is a quite different tale in the foreign universities which not only provide immense facilities for the study of that subject on a very high standard but also for training teachers in Geography. In the opinion of Dr. Chatterjee Geography is still taught in old discarded way by untrained teachers who are lamentably ignorant of the real Geography. As a result of that, boys only get by note names of some cities and towns and some definitions of geographical terms, which is no geography at all.

In his healthy and thoughtful suggestions, Dr. Chatterjee told that in primary school and in the lower forms of the secondary school, Geography should be correlated with that of hand work, nature-study and history, in as much as nature study lessons mainly mean the observation of plant and animal life and of physical environments of the children, which, again, are the stepping stones to the study of geography. In fact, the primary object of the teacher would be to awaken children's interest in their immediate surroundings by arranging geographical excursions. In the higher forms of secondary schools and in the advanced course in geography at the university stage, Dr. Chatterjee said that geography should be taught as a separate branch of science only by those trained teachers who had a clear knowledge of the proper aim and method of modern geography; otherwise this subject would run the risk of being side-tracked by other sciences.

Lastly he suggested that a circular letter would be drafted and sent under the signature of the eminent Geographers present in the Conference to all universities, stressing the importance of geography and requesting them to provide facilities for the higher study of Geography. And geographical associations would be formed in every province with a view to creating public opinion in favour of geography.

He hoped that after such provincial associations have come into existence, a central organization with a central museum can be formed that would help schools and colleges in various ways.

After this a lively discussion followed and a large number of delegates participated in that. Miss Mary W. F. Waddington of Madras pointed out several difficulties that hampered the teaching of geography in different types of schools. In her opinion syllabus for geography is not properly

drawn out; some where it was stereotyped, some where it was too extensive.

MESSRS. GEORGE KURIYAN and S. M. AYYAR of Madras stressed the need for entrusting that subject only on the trained teachers for teaching so that the subject might be properly handled; the latter put in a strong plea for the general recognition of the importance of study of local geography at all stages.

MR. C. RAGHUNATHAM of Madras suggested that geography should be taught in elementary schools as that formed the real foundation for the study of the subject at all the higher stages.

MR. A. N. BASU of Calcutta divided the problems of geography teaching into three classes:—(*a*) paucity of the right type of teachers, (*b*) paucity of materials, and (*c*) paucity of good text books. Dwelling on the third problem, Mr. Basu said that most of the text books were written from the standpoint not of Indian students but of students of other climes and countries. This sort of text books, in his opinion, makes the subject an unreal one. He laid emphasis on the fact that geography should be taught entirely from the standpoint of the Indian students, so that the subject might be well grasped by students.

MR. A. K. BANERJEE of Calcutta endorsed the view of his previous speaker about the need for good text books. He deplored the paucity of materials in high schools of Calcutta which hindered a great deal the teaching of geography on the modern line. In his opinion, geography teachers should be geography-minded and this would be possible by opening geographical societies in different parts of the country.

MISS GASPER of Calcutta put in a strong plea for plenty of out-door work, use of one inch maps and nursery rhymes and this would inspire the boys to use their powers of observation in the study of physical and the human aspects of the Home Region.

DR. L. DUDLEY STAMP of London opined that the basis of the whole trouble is that there is movement in a vicious circle, which has to be cut down somewhere. In his opinion, if the teaching of geography in schools be improved, there will be considerable improvement in the teaching of geography in colleges. In the actual teaching of the subject, he said that the teacher of geography has to keep to himself the purpose of geography and the logical sequence of it and only then text books can be made interesting and real.

MR. N. SUBRAHMANYAM of Madras in rounding off the discussion was at one with Dr. Stamp in his view and added that progress should be made all along the line in order that it may be effective and permanent. He opined that university authorities should be persuaded to take immediate steps to provide facilities for the study of geography and give requisite training and insist upon the right qualification for the teacher of geography, while it is incumbent on the geographical associations to create the proper public opinion.

## VIII. ANIMAL ECOLOGY IN RELATION TO INDIA.

### *(Section of Zoology.)*

A discussion on 'Animal Ecology in relation to India' of the section of Zoology was held in the Zoology room (Chemistry Room I, Presidency College, Calcutta) on the 4th January, 1938 at 10-30 A.M. under the chairmanship of the President of the Zoology Section, Prof. G. Matthai.

1. PROF. P. R. AWATI, Bombay, opened the discussion.

Ecology is a new name for the old subject, Natural History. The old Natural History methods are now looked upon with some disfavour, since they aimed mainly at the collection of specimens. With few exceptions (e.g. the Bombay Natural History Society), local Natural History Societies, however much they catered to the popular interest, do not seem to be of service to modern Ecology.

Ecology is scientific natural history that attempts to explain the physiology of organisms. It is a disciplined study of organisms in relation to environmental factors such as light, air, water, soil. It is the study of the action, and reaction between organisms and their environment, as well as among the organisms themselves.

India is perhaps witnessing the last phases of the old Natural History. There are several Natural History Societies and Museums in India whose collections are often ill-assorted, ill-classified, badly preserved and wrongly labelled, to be of any scientific use. Ecological investigations are sometimes conducted by those interested in the applied sciences. In departments such as Agriculture and Medicine, for fighting pests of crops, and germs of disease.

Ecology has not yet found a place in the curriculum of university studies, although in western countries attempts are being made to give it a place in university syllabuses. Julian Huxley would like (so would we) to see some of the new subjects such as Animal Ecology, Developmental Physiology (Entwicklungs Mechanik), Genetics, Animal Behaviour, taught side by side with the old traditional subjects, Comparative Anatomy, Physiological principles, Cytology, Histology, Evolution and Systematic Zoology.

Students who take a post-graduate degree by an examination only should be required to study the principles (elementary, of course), of these new subjects, in addition to an advanced study of the fundamental branches of Zoology, whilst those who are required to do some research work in addition to a written examination would be well advised to undertake ecological investigations. When, however, a graduate degree is sought solely on research, an ecological thesis might not be regarded as 'safe' for that purpose.

2. PROF. C. R. NARAYAN RAO, Bangalore.

*The distribution of Batrachians in Mysore.*

The plateau of Mysore surrounded on three sides by mountain ranges and by level plains towards the east, is diversified by physical characteristics such as heavy forests and hills raising into bare crags in the higher altitudes, and level plains deriving their character from the means of water supply and the nature of the soil determining the cultivation. The fauna of the country especially towards the west is, in richness and variety, comparable with that met with in Malabar and Travancore.

The tropical forests present a vertical series of strata available for animal occupancy, and the inhabitants of these areas are distinguished by certain well-defined morphological features. These adaptative modifications are closely correlated with the physical conditions of existence, such as humidity, air movements, light and leafy covering of the ground area and the nature of the soil. The trees and shrubs which provide shelter may be classified under the following heads: (i) trees extending here and there up to 80 ft., (ii) lower tree tops, from 40 to 50 ft., (iii) small trees, 20 to 30 ft., (iv) higher shrubs, above 10 ft., and (v) forest floors and low shrubs.

The leafy canopy casts a heavy shade, preventing grass from growing in the deeper recesses of forests, and here the deciduous leaves preserving moisture and warmth, provide protection. The temperature in the deeper

regions of the forests is comparatively high, ranging from 100 to 115° F. while in the margins of the forests the temperature rarely exceeds 100° in the hot weather.

The warmth of the air saturated with moisture makes the tropical forest of the Malnad area a paradise for tailless amphibians. Generally speaking they are slender in build. They are almost entirely of arboreal habit, a few are rupicolous, so much so that, except during the breeding season, they rarely descend. In accordance with such habits, we find that the digits are provided with extensive adhesive discs with aborted web. A few Batrachians build leafy sacs on branches overhanging the water for depositing their eggs in, so that the larvæ fall into the water on hatching.

If we travel from the plains towards the Malnad area, we find there is a marked contrast in the distribution of the several families and even the members of the different genera. Certain species belonging to the genus *Rana* are absolutely plain-dwellers, not represented in the Malnad or in the margins of forests or in the higher altitudes, though a few hardier species may be found even on the tops of the bare crags. In the margins of the forest the principal genera are *Nyctibatrachus*, *Rhacophorus* and *Philautus*. The latter genus is entirely absent from the plains. In the plantations which have sprung up near the margins of forests, a large number of *Engystomatidæ*, principally of the genera *Ramanella* and *Microhyla* are represented. Curiously they are also arboreal while their congeners in the plains are burrowers, a habit of life which has produced remarkable morphological variations. The structure of the skin is equally interesting, inasmuch as the dermis possesses large spaces for the retention of water, a provision against the extreme dryness which prevails during the hot weather.

The paper gives an account of the distribution of the Batrachians in accordance with the physical variations of the country, and describes the morphological adaptations produced by climatic and other ecological factors.

3. DR. SUNDER LAL HORA, Calcutta.

*Animal ecology of torrential streams.*

The author explained how the 'association' of a torrential fauna could be grouped into well-marked 'habitats' which could be further classified into a number of 'strata'. The physical and biological conditions which influenced the distribution of animals into 'niches' were discussed and it was shown that the presence of an organism in a particular type of environment was not a chance occurrence, but was the result of an adjustment of the animal to the external conditions of its existence. By a series of examples. taken both from the vertebrate and invertebrate fauna of rapid waters, the author illustrated that this close adjustment of an organism to the external conditions of its existence or 'adaptation' was brought about through a series of gradual changes in the build of an animal which were, in the main, induced by a number of factors composing its environment. It was concluded that for the study of organic evolution and adaptation it was of the highest importance that animal structure should be thoroughly analysed in terms of its environmental factors, and by such an analysis all chances of confusion arising out of a similarity of structure under apparently different conditions or of a divergence of structure under apparently identical conditions would be eliminated.

4. DR. H. SRINIVASA RAO, Calcutta.

*Ecology of animals living in brackishwater areas of India.*

The term 'brackishwater' is restricted to such areas of water as have permanent or temporary communication with the sea by estuaries

of rivers, or of channels connecting marshes, swamps, and backwaters on the coasts of the Indian Empire. The waters of the areas under consideration are very variable in salinity throughout the year due to the rise and fall of the tides, or to the periodical influx of freshwater from floods and rainfall during the rainy seasons. Certain inland streams and lakes, the high salinity of which is due to purely local causes, as for instance in the streams of the Punjab Salt Range and of Seistan, are excluded from the meaning of the term ' brackishwater '.

The brackishwater fauna of the Indian Empire is as yet little known, but certain typical areas such as, for instance, the Gangetic Delta and the Calcutta Salt Lakes, and the Chilka Lake have been more fully investigated than the others. Preliminary surveys of the fauna of the Vizagapatam, Ennur, Adyar, Travancore, and Cochin backwaters, all of them in S. India, have yielded results not unlike those obtained for the Gangetic Delta and the Chilka Lake, but no detailed observations in regard to the ecology of animals constituting the fauna have as yet been made.

The main types of environment in brackishwater areas may be enumerated under the following heads :—

1. The bottom—of mud, sand, or rock.
2. The inter-tidal region—of mud, mangrove or rock.
3. The weeds—consisting of flowering plants and algæ.
4. The mid-water.
5. The surface-water.

The groups of organisms that are associated with these types of environments are considered. They are of mixed origin—some being marine and some brackishwater, others being freshwater. Certain species of animals are periodical immigrants when salinity conditions are favourable. They die out when they are no longer able to withstand marked and sudden changes in salinity. Certain other species which are well adapted to changing conditions of salinity become the permanent inhabitants of the areas. These are usually of brackishwater origin.

The causes of migration of marine as well as freshwater animals from their habitual environment into brackishwater areas are analysed.

The conditions of life in brackishwater areas, particularly as regards availability of food, competition from various animal species, temperature, chemical and physical conditions, are considered.

5. Dr. H. S. Pruthi, New Delhi.

*A brief review of the work on the influence of the chemical and physical conditions of water on the bionomics of freshwater fauna in India.*

The freshwater fauna of various tropical countries have received considerable attention during the last 40 years, but most of these studies are of purely systematic character. Many problems with regard to the biology, distribution and mutual relationships of the components of various faunas yet await solution. It is now widely recognized that the most essential work preliminary to the solution of such problems is the thorough study of the environments under which the various animals live. Whereas the fresh waters of the temperate region of the world have been exhaustively studied from this point of view, those of the tropics have yet received very scanty attention. Less than a dozen workers distributed over South America, East Africa, India, Ceylon, Java, Sumatra, Bali, etc. have yet investigated the chemical and physical conditions of tropical freshwaters and the influence of these conditions on their faunas. The workers in other countries who have made important contributions to this subject are P. Van Oye. Apstein, Worthington, Carter and Beedle, Ruttner, etc.

In India Senior White, Hora and Pruthi have been engaged on this line of work. Senior White studied the distribution of mosquitoes in

relation to the nature of waters in Ceylon. Hora has paid considerable attention to the physical conditions of rapid waters on fish and other animals in several parts of India. Pruthi critically examined the seasonal changes in the conditions of the Museum tank in Calcutta and studied their rôle in causing periodic epidemics of fish mortality in that water. He also investigated the conditions of life in the highly saline waters of the Salt Range, Punjab. A brief account of the results of important works of these authors will be given.

6. PROF. R. GOPALA AIYAR, Madras.

*Marine biological research in India with special reference to plankton, and growth and reproduction in marine animals.*

Early marine biological research in India is bound up with the work of Alcock, Annandale and Sewell as Surgeon Naturalists of the R.I.M.S. Investigator or as Directors of the Indian Museum, Calcutta. The investigations of Herdman in connection with the pearl fisheries of Ceylon, of Gardiner and others on the fauna of the Maldive and Laccadive Archipelagoes have greatly added to our knowledge of the marine fauna of the Indian Coast. It may be said that systematic Plankton work has not been attempted in India. Various organisms, however, which form constituents of Plankton have been the subject of intensive studies amongst which Col. Sewell's work on the Copepods and the Salpa of the Indian Seas, the work of Doncaster, Browne, Stiasney and others on Sagitta and Medusæ of the Arabian Sea may be mentioned. In recent years a fair amount of work has been done on Plankton and Planktonic forms on the Madras Coast. A comparison of the Plankton of the Irish and the English Seas with that of the Madras Coast is instituted and it is shown that here the Phytoplankton shows definite seasonal maxima. A comparison is also made with the Plankton of the Australian Coast. The influence of sunlight, temperature, salinity and chemical constitution of sea water on Plankton is briefly discussed.

Investigations regarding the periodicity in breeding of tropical animals of the Indian Coast may be said not to have been attempted at all. With the exception of the work of Herdman and Malpas on the pearl oyster and the work on Trochus by Rao no detailed published account exists on the behaviour of tropical forms in regard to breeding in Indian waters. Recently (yet unpublished) work on a number of sedentary organisms growing in the Madras Harbour goes to show that the views of Semper, Orton and Mortenson regarding the breeding of tropical animals cannot be taken as altogether correct. Evidence is available to show that breeding in the Madras Coast is very similar to that of the Great Barrier Reef. It may be said that the breeding of animals in the tropics may be grouped under five definite heads. 1. Single breeding period not lasting the whole year round. 2. Continuous breeding all year round but more active during certain portions of the year. 3. Continuous breeding throughout the year without any marked breeding in any part of the year. 4. Two breeding periods in an year with a quiescent phase in between. 5. Discontinuous breeding related to the phases of the moon. Work done here is in almost complete agreement with the results obtained by the Great Barrier Reef Expedition.

Regarding growth and attainment of sexual maturity the data gathered from the Madras Harbour, taken in conjunction with the information available on work of a similar kind carried out in other parts of the world with very similar climatic conditions, show that sexual maturity is attained at an astonishingly early period and several broods are produced during the course of the year. The rate of growth here is found to be extremely rapid as compared with forms in other parts of the world.

7. **Prof. B. K. Das, Hyderabad.**

*Animal Ecology with special reference to the evolution of the Indian air-breathing fishes.*

The following points were discussed by the author :

1. The various types of ecological conditions existing in India and other tropical countries, and their relation to the characteristic features of the faunas found in such localities.

2. Main factors responsible for the evolution of the air-breathing habit :—

(a) Lack of oxygen in shallow waters is the main stimulus for the instigation and development of this habit, and is of the greatest bionomic importance.

(b) Other environmental factors associated with pools and ditches (stagnant waters), swamps, rivers and streams, lakes and seas, littoral and other zones.

3. Various kinds of adaptations leading to structural modifications as correlated with ecological conditions. As a rule the adaptations are quite new, distinct and of independent origin, but in a few cases they may represent a single phylogenetic type.

4. Certain general characteristic features of the air-breathing fishes —cf. similar environmental conditions prevailing in different parts of the world have led to identical physiological adjustments—a very interesting case of ' parallelism in evolution '.

5. If an organ is modified for aerial respiration it must have (i) air passing in and out of that organ, and (ii) have a capillary net-work—both these conditions are being satisfied by the accessory air-breathing organs.

6. The accessory respiratory organs are chiefly an adaptation for the absorption of oxygen from the atmosphere, whereas the gills form the main seat for the excretion of $CO_2$.

7. In the evolution of air-breathing habit, as a direct reaction to the low concentration of oxygen in the surrounding medium, there is clear evidence of a change of function, followed by structural modifications.

8. Air-breathing habit is the starting point for a series of adaptations that must have helped migration to land, and is a prelude to the whole sequence of later changes that must have led to the evolution of higher vertebrates.

9. Lack of oxygen in tropical waters must have played a most important rôle in the evolution of the terrestrial vertebrates—it is generally believed that the emergence of these vertebrates must have taken place in some such environment, viz., shallow tropical fresh waters or swamps (in other words, semi-aquatic habitat) exposed to occasional droughts.

8. Dr. S. C. Law, Calcutta.

*Ecology of avifauna in India.*

The correlation between the geographical environment and different forms of life, which is so readily observable among plants, holds good in the case of the avifauna of India as well. The subject, however, has only begun to be investigated, and not more than a few pioneer studies are available.

The scope of the paper is limited to certain ecological facts concerned with the avifauna of two particular regions, viz., Lower Bengal and the Himalayan region round about Darjeeling, which came under the investigation of the writer.

Lower Bengal is a deltaic region and has all the characteristics of a delta. The Darjeeling region, on the other hand, is composite in its

geographical character and presents features common with tropical or sub-tropical regions at lower elevations, and temperate and sub-alpine characters at elevations ranging from 5,000 feet upwards. These environmental features are also reflected in the avifauna of each of these two areas. The Darjeeling area with its diversified ecological zones harbour a varied avifauna ranging from the forms peculiar to the plains to those specially adapted to high elevation. The plains species like the Shama (*Kittacincla malabarica indica* S. Baker), the Racket-tailed Drongo (*Dissemurus paradiseus grandis* Gould), Harewa or the Goldfronted Chloroposis (*Chloropsis a. aurifrons* Temm. & Laug.) and the Hill Mynah or Grackle (*Gracula religiosa intermedia* Hay) have their habitat in the low-lying belt surrounding the foot of the hills, seldom exceeding a few hundred feet beyond it. The birds of the temperate zone on the other hand roughly populate an area from about the height of Kurseong to an elevation little over 1,000 ft. above the town of Darjeeling. Among the characteristic vegetation of this zone, the mantle of mosses and fernlike growths harbour plenty of insect food for the birds and also provide nesting material and sites. After this comes the zone of the palæarctic birds, the borderland between which and the temperate zone is the haunt of an admixture of palæarctic and oriental or Indian types.

In Lower Bengal the environment of marshes and *jheels* is congenial to wading birds of the family *Rallidæ*. The areas under tillage are inhabited by a different type of avifauna or rather society or association of birds. Of the waders Snipe with its smaller congeners prevails in the low-lying areas. Larks with Pipits are found in the meadow lands and higher cultivated fields. Plovers and Lapwings are no less a feature of these surroundings. Cattle Egrets are a necessary concomitant of the cultivated fields. The backwaters and salt-impregnated *khals* and *bils* harbour Terns and Gulls. Kingfishers appear to prevail everywhere, and so do Doves, Babblers, and Cuckoos. But on scrutiny particular species are found peculiarly attached to certain environments.

Lower Bengal falls directly in the migration route of birds from north to south and *vice versa*, and while it receives the influx, the stream divides somewhat longitudinally when an outpour into the Indo-Malayan region commences simultaneously with a convergence of avine sojourners to Central India. This accession of avifauna, though noticed haphazard at first, readily plants itself in its proper setting. The ornithologist familiar with environmental factors will at once locate the associations that grow up in different settings. The Ducks and Geese arrive in legions, but what for their nocturnal habits and what for their undertaking migration only at nightfall they compel their adjustment without commotion to their habitat or surroundings. The Sunderban areas harbour them in large numbers, and while they still abound in some congenial river-banks elsewhere, their number continues to dwindle appreciably due to diverse causes mainly affecting their environment.

9. DR. B. SUNDARA RAJ, Madras.

*Ecological Research with particular reference to Indian fisheries.*

In most fisheries man simply gathers a wild harvest, without in any way contributing to its creation. Fish therefore live and die in their natural environment and so provide a rich field for the ecologist. The reactions of fish to physical, chemical and dynamic conditions in the sea and fresh water to soil and bottom material, their response to weather and climate, their food habits and life history as adapted to their environment, and finally their adjustments as communities to other aquatic life including a statistical study of their relative abundance, form the bulk of fishery research which is essentially ecological in character.

The basic problems of Fisheries all over the world may be grouped under four heads:—

1. Can accurate estimates of the productivity of fisheries be made?
2. What possibilities are there of extending fisheries to new grounds or of augmenting the production of existing grounds?
3. What, if any, protective measures are needed to prevent depletion of a fishery or to restore a fishery that has declined?
4. Can a rational basis be found for forecasting the success or failure of a fishing season so as to order the efforts of the fishing industry to maximum advantage?

The last two problems at present have little more than an academic interest for us in India, as so far our sea fisheries have only been feebly exploited and the potentialities of the deep sea are practically unknown, while as yet little is known of the biology of our food fish. Studies on the oil sardine, the most important commercial fish of the Malabar Coast, tend to throw light on the causes of the great fluctuations in this valuable fishery but as yet we are a long way from being able to forecast accurately the probable annual fisheries in India as has been done successfully in Europe and America during the last decade. We may therefore confine our attention to the two first questions.

1. Can accurate estimates of the productivity of fisheries be made? The wide investigations made in recent years since the inauguration of quantitive methods in Marine Biological Research by Henson, have proved that the productivity of the sea and fresh water may be greater than that of land per unit area. Leading authorities have held the view that seas which are relatively deficient in plankton, as Tropical waters are declared to be, must be poor in fish. Biological and fishery investigation in Indian seas point to quite a different conclusion. Statistics are available for the West Coast of the Madras Presidency since 1925.[1] The average quantity of fish landed by a fisherman works out at seven tons in a poor year, taking the 1921 census as a basis. For the same year 1925 the Japanese fisherman landed on an average three tons and the Scottish Fishery Report for 1926 gives over twelve tons per fisherman.[2] If the Malabar fisherman with his primitive methods, afraid to go out of sight of his hut, can capture in a poor year more than 50% of the quantity caught by Scottish fisherman, using the most powerful and up-to-date methods and vessels, and able to choose the most profitable fishing grounds, it must be admitted that the Malabar Coast is at least as productive as the best waters open to Scottish fishermen.

Experiments made with trawlers between 1900 and 1930 in Bombay,[3] Ceylon,[4] Bengal [5] and Madras [6] point to the same conclusions. Though the hours of work and the classification of fish caught were not the same for the different trawlers, the results have been reduced more or less to a uniform basis. Catches in Indian waters vary from 19·04 cwts. to 68 cwts. per day's fishing. Corresponding figures for a day's absence from port for English trawlers in 1921 range from 14·62 cwts. to 49·31 cwts. Had Indian trawlers been worked on commercial lines the catches would have been larger. In calculating total catches by trawling, it must be recognized that the more northerly bottom-feeding fish, cod, hake and haddock, and the flat fish, plaice and halibut, which support the great commercial fisheries of Europe and America, are either totally absent or represented by uneconomic species. In India trawl fish consist mostly of sea-perches, jew fish, thread-fins, sea breams, cat fish, sharks, skates and rays. The well-known table fish, such as the various species of seer, mackerel, pomfret, herring and sardine, are mostly surface or midwater fish, and are not usually captured by trawls. Until fishing with seine and drift nets has been done in deep water the total productivity of Indian seas cannot be correctly estimated. In-shore fishing and trawling however have proved the productivity to be equal to that of colder waters, and it is safe to assume that surface and midwater fish in off-shore waters

will also prove to be equally abundant. The Imperial Economic Committee in their report on fish dated 1927 say, 'It is probable that the chief difference is that in the warmer seas there are many more kinds of fish and probably fewer individuals of any one kind'. The rapid metabolism of Tropical species [7] also probably contributes to increased productivity. Most fish in the Tropics breed when they are a year old. The eggs of the Indian shad hatch in 16 to 24 hours while the American shad usually takes 6 to 10 days.[8] Growth in the sub-tropical Californian sardine, *Sardinops cœrulea* is estimated at only 7·9 mm. a year,[9] while the Indian *Sardinella longiceps* reaches 15 cm. in the first year.[10] It has been recently ascertained that the Indian shad (hilsa) grows to 22 cm. in 9 months.[11] In German ponds carp grow at the average rate of 1 lb. per year; in the warmer parts of the U.S.A. at 3 lbs., but a growth of 1 lb. in 70 days is on record for Indian carp. The average annual yield of carp ponds in Europe is 1 cwt. per acre. In South India it is 1,000 lbs. per acre,[12] and with hand feeding may reach 3,500 lbs. per acre.[13] Rapid reproduction and growth may easily account for increased output per unit area, even though the number of fish of any species at a given time may not be as large as in temperate and Arctic seas.

2. What possibilities are there of extending fisheries to new grounds or of augmenting production of existing grounds? The major fishery investigations conducted in India and Ceylon come directly under this category. All the trawling experiments in Indian waters were for the purpose of establishing a deep sea trawling industry. The question of extension, however, is complicated by the possible effects on the existing inshore fisheries, and the disentanglement of the complex problems involved falls directly within the province of ecology.

Our pearl fisheries, which, unlike all other pearl fisheries, occur only in irregular cycles of years [14] present economically important ecological problems, as yet unsolved after nearly a hundred years of research in Ceylon and India. In 1921 there was a sudden and unaccountably large spat fall, though the pearl banks both on the Indian and Ceylon coasts had no oysters worth mentioning in 1920. The nearest outside sources are the Persian Gulf and the Mergui Archipelago, but no spat could travel so far during their short life as pelagic organisms and if they did would surely have left some trace of their passage along the East and West coasts of India. The only reasonable conclusion is that they were bred locally. Hornell suggested the presence of mother oysters in the coral reefs skirting the coast,[15] but after a careful search oysters on the reefs were not found in appreciably larger numbers than on the banks themselves. All other explanations having failed the only other possible source was considered to be mother beds in deeper waters, that is, beyond the reach of naked divers in the Gulf. It is known that beds identical in structure to the known pearl banks exist in 12, 16, 24 fathoms and more on the Indian coast. A careful survey of the continental shelf on the Indian side of the Gulf of Manaar was suggested to the Madras Government but has not so far been carried out for various reasons. So far a bank of young oysters located in 16 fathoms by a preliminary exploration by the Fisheries Trawler 'Lady Goschen' is the only evidence in support of this hypothesis. Great fluctuations and the occasional prolific years of reproduction are due to a fortuitous combination of favourable factors. The presumption is that in such years the oyster spat invade inshore banks and yield the pearl fisheries of Ceylon and India. When normal conditions return the beds shrink back to their usual limits in deep water.

The second problem, that of augmentation of existing fisheries embraces all the elaborate technique of the pisciculturist. So far the need for the culture of the true marine fish has not been felt even in Europe and America and the only evidence of depletion of stock through human agency occurs in the whale, halibut and Pacific albacore fisheries. It is admitted that we cannot maintain any of the true marine fisheries by artificial propagation.[16] The great fluctuations in sea fisheries have been

proved to be the result of years of highly successful reproduction due to a fortuitous combination of favourable factors. The successful generation may then dominate the fisheries for several years. Thus the herring bred in 1904 dominated the commercial captures of herring in Norwegian waters from 1907 to 1919.[17] Similarly in the Californian Sardine (*Sardinops cœrulea*) four dominant year classes were noticed at intervals of two and four years from 1919-20 to 1920-30.[18] Researches on the Indian oil-sardine point to a similar conclusion. The fish caught in the abundant year 1933 were immature. In 1934-35 and 1935-36 only adult fish were caught, the average size increasing slightly in the 1935-36 year's catch. The heavy catches of 1933-34 were due presumably to the favourable spawning of the 1933 summer and the poor catches in the subsequent years to unfavourable spawning seasons.[19]

Turning to pisciculture in inland waters the exotic food and game fishes introduced into India are Brown and Rainbow Trout from England and New Zealand for hill streams, Golden Carp and Tench from Europe and Gourami from the East Indies for the Plains. The Brown Trout has done well on the Himalayas and in the Punjab while the Rainbow Trout has prospered in South India and Ceylon. All attempts to acclimatize the Golden Carp and Tench to the waters of the Plains have failed, though they still breed in Ootacamund Lake. When a suggestion was made by a practical fisherman for stocking with Trout the hill waters of the Punjab which were barren of fish of any value,[20] it met with the most violent disapproval from orthodox zoologists on what appear to be purely theoretical grounds.[21] That the introduction of exotic species should be done with care is reasonable but the objection is valid only where it applies. The introduction of trout on the Nilgiris, where the indigenous fish were of no value at all has caused no regret but has yielded a valuable and successful fishery for over thirty years. Since conditions are similar on the foothills of the Himalayas the introduction of trout is the best practical measure that can be recommended on ecological grounds. The South India and Ceylon experiment affords a concrete instance of the success of the scheme.

The highly esteemed gourami, which is well adapted for cultural treatment and has been bred in Java for centuries, is the chief exotic fish cultivated in all the fish farms of the Madras Fisheries Department. It attains the large size of 24 lbs., feeds chiefly on water plants, is boneless, and has an excellent flavour. Extensive experiments have been carried out in Madras during the last 20 years, and as it is cultivated in small ponds in Java it was assumed that it was only suitable for stocking the stationary waters of protected ponds. So it was never introduced into rivers and lakes. But a few years ago an accident occurred to the gourami pond in the Peradeniya Botanical Gardens in Ceylon when the pond overflowed into the neighbouring river. For years the fish were given up for lost, but in 1935 it was discovered that the fish had established themselves in the river, which is the largest in Ceylon, and were the object of an extensive commercial fishery.[22] The knowledge thus gained opens up great possibilities for the development of river and lake fisheries in India.

Two other exotic fish have been introduced for anti-malarial measures. They are the Barbados Millions—(*Lebistes reticulatus*) and *Gambusia affinis*.

The more valuable indigenous fish have also been made the subject of experiment. For larvicidal measures we have *Aplochilus* and *Panchax*, which have proved to be equal to any imported varieties, and being indigenous are both cheaper and better adapted for use.[23] A recent attempt was made to assess their larvicidal value by examining their gut contents to determine their natural food. As anopheline larvæ were found in only 10% of the fish examined it was concluded that these fish are not partial to a diet of anopheles and are therefore of no value as larvicides.[24] But as Dr. Gravely points out,[25] in small tanks and pools,

whenever the fish disappear mosquito larvæ are at once found, but as long as the fish are there no larva is ever seen. Evidence from stomach contents is not conclusive without more elaborate and critical tests on accepted ecological lines, while practical field experiments have proved the undoubted efficacy of these fish in combating mosquito nuisance.

Among the indigenous food fish that have been cultivated in India are hilsa, several Indian carps (*Barbus*, *Catla* and *Labeo*), an estuarine perch-*Etroplus suratensis*, and the white mullet or milk fish, *Chanos chanos*. Hilsa is a large and highly esteemed fish which ascends rivers for breeding, and extensive and valuable hilsa fisheries exist in all the important rivers of India. Since 1869 the Madras Government have been taking steps to safeguard hilsa fisheries from extinction, and the only satisfactory course was found to be a hilsa hatchery on the Coleroon river. Artificial breeding of hilsa has been successfully carried out in Madras,[26] but the problem of rearing the fry until they are sufficiently large to be liberated into the rivers still remains to be solved. An intensive ecological study of the hilsa was also undertaken and the life history of the fish in its main outlines has been traced, and their rate of growth in the rivers ascertained.[27] How long the fish remain at sea and whether they go to deep waters, when and how often they return to the rivers for breeding, are problems that remain to be investigated.

Catla, one of the largest Indian carp, is specially noted for its rapid growth in all kinds of water (except brackish) from small wells a few feet in diameter to large lakes and rivers hundreds of square miles in area. It is not predaceous and the fry will reach a marketable size of 18–24 inches in seven to eight months, for which period alone most of the irrigation tanks in the Madras Presidency hold water. The natural distribution of the fish stops with the Kistna river and so far it has not been possible to breed it in any of the fish farms. Therefore its general distribution from the Kistna and Godavari to the South of the Presidency is unusually difficult and expensive. It was found however that after the construction of the Kurnool-Cuddapah canal catla spread into the Pennar river, about 150 miles south of the Kistna. This suggested the possibility of establishing catla in the Cauvery but the proposal was condemned by some zoologists.[28] It was declared on theoretical grounds that catla are tank fish and inhabit stationary water, breeding in inundated paddy fields,[29] but as evidence to the contrary from field studies and the positive migration of the fish from the Kistna to the Pennar river systems was conclusive, the scheme was persevered with until success was attained. Eight years after the Mopad Reservoir was first stocked and nearly twelve years after the first stocking of the Cauvery, evidence became available of the success of the scheme. Catla of all sizes now appear in the catches at Mopad and throughout the Cauvery river, thus proving the soundness of the scheme.

*Etroplus suratensis* is a valuable food fish of the sea and backwaters which, though it normally breeds in salt and brackish waters, readily acclimatizes and breeds in fresh water if nesting facilities are provided.[30] It is now extensively bred in the Madras fish farms and is used for stocking tanks.

*Chanos chanos* is another backwater fish largely farmed in the East Indies. Experiments have just begun in its culture in Madras.

Pearl farming is attempted in the Gulf of Manaar. One of the aims of the Krusadai Biological station is the establishment of a pearl oyster park with the twofold object of providing spat from the park when the natural supply of oysters fails on the banks, which adjoin the park, and of inducing cultural pearls in the Indian oyster.[31] Though attempts made during the last eighty years in Ceylon and India only met with failure,[32] the experiments in pearl oyster culture begun in 1933 on Krusadai Island have succeeded. Spat transferred from pearl banks in 1933 are still alive and have grown at the same rate as on the natural banks. They have also bred and the spat produced have grown to adult size without undue

mortality.[33] An important ecological phenomenon observed contrary to all expectation was that oysters live best on mud banks if suspended about five or six feet above the mud bottom, and thrive in bays well sheltered from wind and tides, though the water may be turbid and low in salinity owing to land drainage.

The establishment of catla in the Cauvery, the accidental spread of the gourami to the lower reaches of the Mahawali-Ganga in Ceylon, and the culture of the Indian pearl oyster in shallow muddy bays in spite of theoretical objections demonstrate that academic arguments should not be allowed to outweigh the results of careful ecological studies in the field and of practical experiments. As with all other ecological research, the habits and responses of fish in their natural environment, must provide the foundation for the kind of experiment to be performed and the equipment to be employed in piscicultural experimentation. Initial facts have to be discovered by a study of the fish in Nature. At the same time if culture is to improve on Nature, new departures and a spirit of adventure must characterize experiments. Such a bold departure is no mere leap in the dark. It is wellknown that a fish may be trained to make mental associations otherwise some of the complicated migratory movements of fish especially those of the Pacific salmon, which return to their native hill streams with unerring instinct will be unintelligible. From a purely ecological point of view also, the 'biotic potential' which is the rate of reproduction, capacity for survival, protective reactions and structures found in an animal is but the quantitive expression of the dynamic power of the species, pitted against the resistance of the environment. With changes in the environment the expression or behaviour must also change.

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10. PROF. G. D. HALE CARPENTER, Oxford.

*Ecology.*

Ecology, after all, is only Natural History, organized, analyzed and systematized. An ecologist is born, and not made—let us make the most of those who have the gift. Prof. Awati made the sad statement that ecology is not considered a suitable subject for an advanced thesis because it often leads to no definite result. This seems to be grave indictment of a situation which should not exist.

Regarding museums the ecological aspect of display of collections is far more important for the public than the accumulation of large numbers of specimens to illustrate taxonomy, which is a question for advanced students rather than the general public. A very good beginning has been made in the Indian Museum by Dr. Prashad.

11. PROF. P. A. BUXTON, London.

Prof. P. A. Buxton (University of London) gave a short account of the growth of knowledge about the ecology of mosquitoes. In his opinion the results of many years' work were rather disappointing. He attributed this in part to the fact that the work has generally been done by men working in isolation (the subject demanding a knowledge of water chemistry and physics, algalogy, bacteriology and other matters, and being appropriate to team work), and in part to the fact that observations in the field had not been sufficiently analysed by experiments made in the laboratory.

PROFS. W. M. TATTERSALL, L. F. DE BEAUFORT, and LT.-COL. R. B. SEYMOUR SEWELL, also took part in the discussion.

# IX. THE PLACE OF SYSTEMATICS AND MORPHOLOGY IN THE STUDY OF THE LIVING ANIMAL.

*(Section of Zoology.)*

A discussion of 'The place of Systematics and Morphology in the study of the living animal' of the section of Zoology was held under the

chairmanship of the President, Prof. G. Matthai, in the Zoology section on January 5, 1938 at 10-30 A.M. The President introduced the subject and called upon Col. Sewell to open the discussion.

1. COL. R. B. SEYMOUR SEWELL, Cambridge, opened the discussion.

*The place of systematics in the study of the living animal.*

A study of the live animal can be carried out along several different lines but in every case it is impossible to separate the study of the living and the dead.

Whatever branch of study one may wish to undertake, the first essential is the identification of the animal. The Systematist bases his classification on Morphology, but he is fully aware that evolution s continually going on and that the species is liable to variation. The study of Evolution necessitates the study of Genetics, Distribution and Ecology. Each branch of study is intimately correlated with other branches, and Systematics, which is based on Morphology, is the central pivot around which all other branches are grouped.

2. PROF. K. N. BAHL, Lucknow.

*The place of morphology in the study of the living animal.*

Morphology is an ancient study which forms the basis of orthodox taxonomy and has yielded remarkably valuable results in systematic zoology. It is impossible to study the mechanism of the living animal or its habits and relations to its environment without studying its structure as well, just as it is impossible to understand the working of a motor car without knowing about the petrol feed, the carburettor, the ignition and the transmission gear. Emphasis merely on 'topics' of behaviour, organ-systems, economic applications, etc., tends to vagueness and lack of logical unity. Structure and function go hand in hand and evolve *pari passu*.

Modern views about the anatomical basis of 'reflex action' illustrate the method of an experimental science. Excretory organs and hepatopancreatic glands of earthworms exemplify how morphological studies open up new fields for physiological and ecological work. Study of cytology and its co-operation with physiology and genetics have led to remarkable results in heredity.

3. PROF. H. K. MOOKERJEE, Calcutta.

*The place of embryology in the study of the living animal.*

Animals having similar characters are considered, on the basis of the theory of evolution, to be closely related, and dissimilar structure means distant affinities. The older systematist's task, therefore, was simple, and in building up classification he merely depended upon similarity of structure. With the advance of knowledge it became evident that similarity of structure was not the true test or criterion, and the idea of homology and analogy should be kept in mind when comparing animal structures.

Organs which are developmentally alike are homologous, and morphology, in the wider sense, thus includes science of development or embryology. I shall now cite a few concrete examples from my own investigations on the development of the vertebral column, on which I have been working for a number of years, in order to show the value of embryological evidence on animal structure. These will be in the nature of answering certain questions which naturally arise in connection with the development of the vertebral column. The questions are these :

1. Do all the centra in different classes develop from the skeletogenous layer surrounding the notochordal sheaths as a whole? This question arises since we find variation of shape regarding different forms of centra.

2. As we find variation of thickness and material of centra in the different classes the question is, are the centra of different classes of vertebrata homologous?

3. How are the different types of vertebræ formed, as we find four different types?

4. Variation in thickness in different regions of a single arch or variation in different species is observed, and the question is, are the neural arches of different classes of vertebrata homologous?

5. Why have the Teleostean fishes alone got neural arches made up of membrane bone, and why are they situated either at the anterior or at the posterior extremity of each centrum, and why does the rest of the centrum remain without the neural arch?

6. Is there any marked variation of the development of the centrum within the existing genus, or a marked similarity between two species belonging to different sub-classes? If so, then one is inclined to entertain a doubt as to the validity of the present classification.

4. VISHWA NATH, Lahore.

[In the absence of the author the paper was read by Dr. Misra of the Benares Hindu University.]

*The place of cytology in the study of the living animal.*

In cytology, or the study of the cell, lies the key to the solution of all biological phenomena, for all organisms are made up of cells. Whatever biological phenomenon we may wish to study—it may be structure, function, development or heredity—we are invariably driven to the study of the cell, the unit mass of protoplasm, which forms the physical basis of life.

It is impossible to exaggerate the importance of the study of the living cell. Curiously enough, after the introduction of the compound microscope in 1590, cells were studied in the living state by the earliest observers. But unfortunately, with the development of cytological technique towards the close of the nineteenth century, the centre of interest was shifted from the study of the living cell to that of fixed and stained material.

Fortunately interest in the study of the living cell has been recently revived and valuable results have been obtained through micro-dissection and tissue culture or through the simpler technique of directly studying fresh cells isolated from the body of the organism.

Probably the greatest achievement of cytology is the demonstration that the nucleus of the cell, or more particularly the chromosomes, constitute the physical basis of hereditary transmission. Apart from the most valuable data which have been collected through the study of fixed and stained preparations, witness the recent works of Bêlar, who has studied the whole process of mitosis in the living cell.

With the above most valuable results in hand the geneticists and the students of eugenics are busily pushing forward their experiments with a view to establishing better breeds or races.

On the contrary, the Neo-Lamarchians are laying increasing stress on the importance of environment or habit in the transformation of species; but whatever the *modus operandi* of evolution may be, the chromosomes will continue to be regarded as the vehicle of hereditary transmission.

Beside chromosomes various protoplasmic structures, such as the mitochondria and the Golgi apparatus, have been recently studied in

the living cell, and our knowledge of the structure of the living cell is much fuller today than it was fifteen years ago.

The cytologist will reach the climax of success when he can create life. The bio-chemist, it is true, has isolated from protoplasm various kinds of most complex compounds. But protoplasm is not a mere mixture of these compounds. It is an organized system, the activities of its various constituents being fully co-ordinated. The protoplasmic compounds are represented by particles which vary endlessly in chemical nature, physical consistency, degree of magnitude and physiological activity, and are constantly acting and reacting upon each other. Until we understand the true nature of these reactions life will continue to be an unsolved puzzle, and the manufacture of protoplasm a cherished dream.

5. Dr. A. B. Misra, Benares.

Dr. Misra stressed the importance of Cytogenetic studies and showed that the variations can be expressed by the various assortments of genes in the chromosomes by linking and crossing over of chromosomes.

6. Prof. W. M. Tattersall, Cardiff.

Systematic Zoology is essentially concerned with the classification of animals and it is the business of the systematists to evolve a natural and true classification of the animals he studies. Hitherto such work has been mainly morphological and for certain animals at least, e.g. the deep sea fauna, must of necessity remain so. Workers on the systematics of terrestrial and shallow water forms, however, are realizing more and more the necessity of studying the living animal if the morphological facts which are the basis of their work are to be correctly interpreted and given their true value in the classificatory scheme. Stephenson in his recent monograph on British anemones has even suggested a major classification of the group on characters which can only be observed on living animal, namely, the method of reproduction, and more or less definitely states that it is impossible to identify correctly a preserved anemone.

As a worker on the systematics of Crustacea I would emphasize the value of the study of the living animal whenever possible and particularly in regard to the following points:—

(1) The morphological changes which accompany growth and more especially growth which takes place after sexual maturity has been reached. Many Crustacea become sexually mature before full growth has been attained and many species have been described which have subsequently been found to be merely growth stage of already described forms. The phenomenon of high and low dimorphism is particularly important in this connection;

(2) the changes which accompany the growth of organs and structure which are regarded as fundamental for classificatory purposes, e.g., the genitalia in many groups of crustacea;

(3) the study of the functions of various organs and structures as a guide to the proper interpretation of their morphology, to an accurate assessment of their real value in classification. I would specially mention here the work which has been done on the feeding mechanism of Crustacea, and on the locomotion or Crustacea for a proper interpretation of the internal musculature.

What is said above about crustacea will probably apply in large measure to other groups of animals. Hora's work on the fauna of mountain torrents, Das' work on the respiratory adaptations of fishes, and Wood Jones' observations on the function of the syndactyl digits of marsupial are notable examples of the valuable results to be obtained from observa-

tions on living animals in the true interpretation of morphological characters.

Systematic zoologists are ultimately concerned with the mechanism of evolution and one of their main problems is to elucidate the cause or causes which have led to the formation of the genera, species and varieties which they describe. Specially important is the study of biological races which can be regarded as species in the making. Such races in many cases are morphologically inseparable, but differ in some biological characters, such as the nature of the food, times of reproduction and so on. For a proper understanding and appreciation of these differences observation on living animal are fundamental and it is in such studies that the ultimate solution of the mechanism of evolution must be sought.

7. PROF. L. F. DE BEAUFORT, Holland.

When we consider the history of morphology we see that after Darwin morphology was merely concerned with phylogeny of organs and therefore the study of *homology* stood on the foreground. We have, I think, fairly got to the end in this way of investigation and now another way of looking at morphology has arisen, where the *function* of the organ is put on the foreground, which involves the study of the living animal. Analogies are studied now and I wish to point out the recent work of Boker, who started quite a new kind of comparative anatomy, which he calls *Biological Comparative Anatomy.*

Dr. B. Prashad, Calcutta and others also took part in the discussion.

## X. BLOOD GROUPINGS AND RACIAL CLASSIFICATION.

*(Section of Anthropology.)*

The proceedings of the Anthropology section of the Indian Science Congress began on Tuesday, 4th January, 1938 with an address of welcome by the President, Dr. B. S. Guha, to the foreign delegates and to those who had come from other parts of India.

Before the routine work of the section began Mr. K. P. Chattopadhayaya, Calcutta, moved the following resolution:—

That this section records its deep sense of sorrow at the death of Diwan Bahadur Dr. L. K. Ananthakrishna Iyer, M.D. (Breslau), who was for some time the Head of the Department of Anthropology, Calcutta University, and whose contributions to Anthropology had won for him a recognized place among the leading Anthropologists of the world.

The resolution was passed unanimously all standing.

As already arranged the discussion on 'Blood Groupings and Racial Classification' took place at 1-30 P.M.

### *Blood Groupings and Racial Classification.*

The President, Dr. B. S. Guha asked Dr. E. W. E. Macfarlane to open the discussion.

In opening the discussion Dr. Macfarlane referred to the researches of the Hirschfelds who first drew attention to the high percentage of B in Indians and to the descending values of B as one passes westwards from India. Similar proportions in Gypsies, Colonial communities and their relatives in the home country led many Anthropologists to think of blood grouping as a reliable rest of relationship. The speaker also pointed out that Group O was the oldest and original ancestral group. The group A appears to be very old while B appears to be of recent origin. The dis-

tribution of B has led Synder, Gates and others to conclude that the gene is not derived from the joint ancestors of the anthropoids and hominidæ but has arisen in both as parallel mutations.

In India there are distinct coeval races in every district which have been effectively isolated by the prevailing customs of caste endogamy. There are also communities possessing a preponderance of each of the three alleomorphic genes for blood groups. In south-west the low caste peoples have a very high proportion of group O, and the Hill tribes are righ in A. It has along been known that the greatest concentration of group B is in India, but only within the last few years has an attempt been made to get data from each caste and tribe from each locality separately. Those data are urgently needed and must always be appraised in relation to past migration, isolation, inbreeding and other physical characters of the groups.

It is possible that serological data from India may throw light on the origin of the B gene and also upon the mutation rate. The frequency of B is greater among all the Bengali depressed classes, among the Todas and the 'Dravidians' of Chota Nagpur than in any other peoples. The Cochin State is the only region in India where the frequency of B is less than of A. The frequency of B is lower among the mixed population in Assam, Burma and Tibet than in the Ganges valley, and therefore if B arose independently among the Mongolian tribes it has spread west and south from China. In south Bengal the frequency of A differs little in all communities and B therefore seems to have originated as a mutation direct from O (or R). Mutations to B should still be going on in some stocks and we may find communities with high percentages of group O and of B.

Lastly, the speaker stressed the fact that miscegenation is now becoming more common and it is important to get data as quickly as possible. Further the agglutinogens are supposed to have no selective values and it is very difficult to explain how B spread east and west of India through hybridization. The speaker, however, concluded with the remark that blood grouping is an aid to anthropology; it cannot be alone used for solving a relationship but must be taken into consideration with other racial characters.

Frhr. von Eickstedt of the University of Breslau pointed out how in Germany they were mainly concerned with zoological types and opined that blood grouping may determine physiological types and not the zoological types of India.

Prof. Ruggles Gates said that the blood groups are definite units whose method of inheritance is known. This gives then a great advantage over all physical measurements as indices of racial relationships; for such differences are not only quantitative and subject to fluctuations but the manner of their inheritance and for example, the relation of the cephalic or nasal indices to genic differences is at present largely a matter of conjecture.

The use of the blood groups in connection with racial classification and relationship is largely based upon the development of the theory of mutation frequencies, as he has shown in Genetica, Vol. 18, pp. 47–65, 1936. Like other mutations, they must occur repeatedly with certain frequencies which are low but they undergo changes. The evidence indicates that such changes in frequency are more likely to be sudden and marked than gradual. The evidence also supports the view that O was the original condition in mankind from which A and B have been derived by dominant mutations of the order of frequency of perhaps 1 in 100,000. Since parallel mutations are so frequent in other characters, it is not surprising if A and B have developed as parallel mutations in the Hominidæ and the Anthropoideæ.

The speaker stressed the fact that in comparing the blood groups of different races the results need to be interpreted in terms of (1) isolation, (2) migration, (3) racial crossing. He also suggested that future blood

groups tests should be combined with anthropometric and other measurements in the same individual, since they will help in elucidating the history and relationships of races.

Prof. Gates illustrated his lecture with lantern slides citing examples from India, Tibet, North Africa, Arabia and North America.

PROF. H. J. FLEURE pointed out that it seemed desirable to him that the blood characters of the individuals should be recorded along with other physical characters of the same individual and he hoped that it was in that, the correlations which were not yet sufficiently demonstrated could be found out.

PROF. CREW mentioned that it was not impossible that blood groups genes might ultimately be used as genetic markers warning us of their association with lethal genes affecting, for example, the secondary sexual ratio and infantile mortality.

MR. A. ANANTHANARAYAN AYER said that the value of blood grouping for giving some evidence about parentage in medico-legal work and between two races living close together was unquestioned, but to use figures of blood grouping to interlink zoological races in different parts of the world seemed irrational. According to him it could only be of very secondary importance to other fundamental anthropological data.

In summarizing from the chair Dr. B. S. Guha remarked that blood grouping must not be taken to supplant our views about racial relationships derived from anatomical characters but they should be considered as furnishing valuable data of a supplementary character, specially of the physiological behaviour of different communities but exactly how they are related to other anatomical characters, we are not quite in a position to judge at present.

## XI. A PROGRAMME OF ARCHÆOLOGICAL EXCAVATIONS FOR INDIA.

*(Section of Anthropology.)*

Discussion on 'A programme of Archæological excavation for India' took place on Friday, the 7th January, 1938 at 2 P.M. with Dr. B. S. Guha in the chair.

In opening the discussion Rao Bahadur K. N. Dikshit said how Archæology in earlier days, i.e., about 75 years ago was mainly confined to excavations here and there without any definite purpose and that it was reserved for Sir John Marshall to give it a systematic turn with a definite purpose. Referring to the epoch-making discovery of M[illegible]daro which opened a new chapter in the history of India Rao Baha[illegible]ted how for want of sufficient funds from the Government for the last six years, nothing could be done except the preservation of the things already excavated. Citing a long list of the pre-historic sites still awaiting the spade on the archæologists, he urged the systematic excavations of the two sites of Harappa and Mohenjodaro, as they were likely to supply many of the missing links in the cultural sequences of India. As regards the other pre-historic remains the speaker mentioned the Asura sites of Chota Nagpur, which are full of copper ores; the megalithic site in Burdwan, Bengal; the numerous (about 200 in number) sites in Peshawar, the birth place of the Grammarian Panini; the paleolithic sites in Central Provinces and other sites in Bombay Presidency, Maharatta country and Madras. Rao Bahadur concluded by saying that many things were being ruined surreptitiously and it was high time that systematic excavations should begin at once. He thanked the Government that at present it had placed

a comparatively bigger sum for archæological investigations and that he hoped that work would begin very soon.

MR. N. G. MAJUMDAR who followed, impressed on the necessity of a complete survey of Sind and the contiguous state of Las Bela in Baluchistan.

RAI BAHADUR R. P. CHANDA pointed out that ancient river beds, such as Saraswati, Sravasti and the river beds of Arabia might reveal many important discoveries.

MR. K. P. CHATTOPADHYAYA said that the Archæological Department should pay more stress on Pre-historic Archæology and not allow outsiders to exploit the valuable treasures in India and urged that Government should take in Indian scholars trained both in Anthropological and Archæological works.

DR. M. H. KRISHNA also referred to the sites in Mysore and pointed out the similarity of Mysore discoveries with those of Maski in Hyderabad.

PROF. PEAKE pointed out that it was time that we should depend on the spades for truth rather than build theories on tradition and linguistic studies. According to him Indus civilization connects Indian prehistory with neighbouring regions and he urged on the utility of trial excavations in numerous sites with the resources at hand. He also pointed out the necessity of arousing the interest of the rich people and said that trained experts from Europe could be sent to conduct the works of excavations if necessary.

PROF. FLEURE thought that excavations of the megalithic sites was very important specially in India where there were still people connected with megalithic culture. He was of the opinion that this might throw light on the pre-Aryan civilizations of India.

PROF. THOMAS was of opinion that India with her numerous pre-historic remains should be the centre of an Archæological Institution to which students should flock for training on the spot.

In concluding the discussion the President pointed out how originally Archæology in India was concerned only as a department of history and confined itself mainly to the preservation of ancient monuments and the decipherment of Sanskritic and other written inscriptions. Prehistoric Archæology in the sense in which, it is understood in Western countries was not studied in India. With the discovery of Mohenjodaro its importance has recently been somewhat realized, but this realization is still very partial. For the proper study of Archæology and a scientific reconstruction of the unrecorded history of India it is essential that the Archæological Survey should be reconstituted into a department of Explorations and a department of the preservation of ancient monuments. In the former only people with Western training with experience of excavations in Europe and the Near East should be recruited to excavate and study the innumerable prehistoric sites in this country. With the materials thus recovered it would be possible to build up a correct account of the past history of this country.

## XII. THE IMPORTANCE OF ANTHROPOLOGICAL INVESTIGATIONS FOR INDIA.

*(Section of Anthropology.)*

Discussion on the importance of 'Anthropological investigations for India' took place on Wednesday, 5th January, 1938 at 2 P.M. under the Presidency of Dr. B. S. Guha.

In opening the discussion on 'The importance of Anthropological investigations for India' Rai Bahadur S. C. Roy of Ranchi pointed out that anthropological investigations should no longer be considered as a pleasant diversion. It is time that proper attention be paid to this direction especially in India when her administrative systems is undergoing a change calling for a definite well-considered scheme for the promotion of economic, educational and social interests of her aboriginal population. The different universities of India do not seem to be very alive to the importance of the study of anthropology. It is only in the Calcutta University that Anthropology has been accepted as a subject for post-graduate studies and the universities of Mysore, Lucknow and Bombay have introduced it partially in the post-graduate studies in recent years.

Uptill the present, neither the Central nor the Provincial Governments appear to have paid any particular attention to this matter or at any rate to have formulated any definite policy regarding it. In Europe, Anthropology is a compulsory subject for the Civil Service Examinations specially for those who are competing for Colonial service. But in the Indian Civil Service Examination although it was originally an optional subject, it is now omitted from the list of subjects for the examination held in India. Rai Bahadur Roy stressed the fact that many primitive tribes were dying out and a proper and thorough enquiry into their customs, institutions and mentality was urgently required. Administrative, moral and humanitarian points of view demand that Government should grant adequate funds for the study of the backward and excluded and partially excluded areas. Fortunately the Government of Bombay has in the year 1931 made a gesture in this direction. An attempt is being made there to ameliorate the position of the backward and depressed classes by appointing special officers and spending on an average Rs.35,000 a year.

Rai Bahadur Roy showed from two specific instances from Chota Nagpur how the want of a proper knowledge of the institutions of the primitive people in several cases led to misunderstanding in the minds of the Government officials and how a serious riot was avoided by handling the people with tact and wisdom born of a knowledge of their mentality, customs and beliefs. He concluded by showing the importance of Anthropological study in national life; how a proper understanding of the different peoples, primitive and advanced, might supply a bond of unity between the different communities and ultimately in the realization of a common nationhood.

Mr. K. P. Chattopadhyay who spoke next pointed out what an extensive area in India still remained unstudied. He referred among others to the work specially of Rai Bahadur Roy in Chota Nagpur area and of Dr. Hutton in Assam. He thought that a proper understanding of the material culture and economic condition would help the formulation of a proper scheme of national education. He also pressed the need of an extension of the study of Anthropology.

Baron von Eickstedt said that so far as biological anthropology is concerned very little has been done so far in India but in social anthropology a somewhat greater progress has been made.

Mr. A. N. Chatterji thought that the anthropology of the higher castes was as important as that of the primitive tribes. A proper study in his opinion would help us in solving many of the maladjustments of the middle class.

Prof. Fleure pointed out the large amount of anthropological work particularly on the Castes and Tribes done in India. In England there has, in recent years been an attempt to understand Indian condition and after his return Dr. Hutton was given a Professorship in the University of Cambridge in recognition of his work in India. What was needed now

was to approach the Government of India and to lay stress on the importance of anthropological studies for administrative purposes and get it re-introduced as a subject in the Indian Civil Service. He promised to do his best both in England and India on this matter.

PROF. PEAKE also pressed the necessity of the study of the middle and upper classes along with the study of the primitive and lower classes.

In summing up the President said that the necessity of anthropological investigations from both the social and physical points of view was very great in country like India inhabited by so many races of diverse cultures and languages. It is only through the study of anthropology and not by any amount of pious wishes could these divergent and hetrogenous elements be welded into a nation with common national outlook and ideals.

RESOLUTIONS:

In the meeting of the Anthropological Section, 25th Indian Science Congress on the 8th January, 1938 the following resolutions were passed:—

Prof. H. J. Fleure, F.R.S., of the University of Manchester, moved that:—

'This conference is of opinion that in view of the urgent necessity of an intensive study of biological traits and social institutions of primitive as well as of advanced peoples and cultures in India, it is essential that the Universities and Provincial administrations should make adequate provisions for the teaching of and research in Anthropology.'

'That in order to promote such work, the Central Government be requested to give an independent status to Anthropology as a department of research.'

Prof. Baron von Eickstedt of the University of Breslau seconded the resolution.

The resolution was carried unanimously and it was decided to request Dr. B. S. Guha to draft a reasoned statement in support of the resolution which could be forwarded by the Executive Committee to the various authorities concerned.

Prof. F. W. Thomas of the University of Breslau moved the next resolution:—

'That for proper research in Archæology it is necessary to have a Central Institute of Archæology and Anthropology in India on the line of such institutions of Europe and America as problems of prehistoric archæology and Anthropology are largely interdependent and common and should be studied together.'

Mr. N. G. Majumdar seconded the resolution and was passed unanimously.

## XIII. IMMUNITY IN PROTOZOAL INFECTIONS.

*(Section of Medical Research.)*

The discussion was opened by Dr. Krishnan.

CAPT. S. DATTA referred to the existing protozoal diseases of domestic stock of India and surveyed the present position. He emphasized the general observation that Indian livestock can withstand protozoon infections better than European or other stock imported into this country.

Due to this relative immunity of Indian cattle, they have found favour in different British colonies and Dominions. The resuscitation of protozoon parasites like Coccidia, Trypanosoma, and blood parasites like Babesia, Nutallia, etc. following upon diseases of virus and other origin is constantly seen all over India and must be an important aspect of the study of host-parasite relationship. With the recently organized Section of Protozoology at Mukteswar Institute, the study of the larger issues of Protozoal Immunity has been commenced.

DR. VISHWANATH said that the connotation of the term immunity differs according to whether you are talking of virus, bacterial or protozoal infections. Against the viruses an immunity of long duration is usually developed and passive immunization is also effective. Complement fixation can also be demonstrated easily. The immunity against bacterial diseases in general carries a shorter duration, passive immunization is of not the same strength as in virus infections and is capable of being assessed by search for antibodies in a greater variety of ways. Immunity against Protozoal diseases is not only incapable of passive transference and rather difficult of assessment through search for anti-bodies but by virtual absence of active immunity arising through infection. This absence of acquired active immunity may be due to the Protozoa as members of the animal kingdom not representing as strong a foreign protein as bacterial flora or viruses do. Apart from control of insect vectors we must look for prophylaxis and treatment to immunological products for both active and passive immunization. We must also look to chemotherapy for the control and cure of protozoal infections.

DR. GHOSH said that there was hardly any quantitative leucocytic response in most of the protozoal infections and this is a significant difference between Bacterial and Protozoal infection. It has been found that by artificially inducing leucocytons by 'Gool' (a primitive indigenous method of inducing leucocytosis) undoubtedly the treatment by chemotherapy, particularly in cases of Kala azar, can be greatly modified.

Another aspect of protozoal infection is that in cases of amoebic infection at least, there is certain amount of loss of power of producing anti-bodies against bacterial infection in the host. This was observed in several cases of chronic Staphylococal Eczema which could not be cured either by vaccine or by chemotherapy. Amoeba having been detected in the stools, a course of emetine with vaccine cured all those cases of Eczema.

DR. SEAL said that he would like to know whether the so-called protozoal immunity is a resistance to super-infection or a real immunity and whether this resistance or immunity is more manifest in malaria or in Kala azar. It is found that after repeated attacks of Malaria up till the age of 12 properly treated or not, a certain amount of immunity is acquired but still the person may remain susceptible to it whereas a person once cured of Kala azar rarely gets a second attack except in a very limited percentage of cases; cases, completely or incompletely treated, remain highly refractory and suffer from a condition called Dermal leishmanoid or Dermal leishmaniasis first noted by Sir U. N. Brahmachari.

DR. POULTON stated that after the treatment of G.P.I. by Malaria, it was in England quite easy to stop the infection with a single dose of quinine. In India, he was informed that it is difficult to stop attacks. The Englishman in India is even more susceptible than the Indian. Is it a question of climate? It would be worth comparing hill stations with the plains, etc.

DR. GANGULI said that he had found response to treatment by quinine and atebrine varied in different persons, a few reacting very quickly and others taking a much longer time, but it had been found that when once the blood had been sterilized with atebrine as confirmed by Bass culture,

the patient did not usually get a relapse. The experiments of Short and others show that even if the blood is sterilized by acridine or atebrine, relapses would immediately occur in a week or two. The effect of the drug has also been found to vary according to the constitution of the person, climate and altitude.

Regarding immunity response in Leishmaniasis, Brahmachari was the first to discover that the Euglobulin factor which is closely associated with immunity, was much increased in the blood of persons suffering from Kala azar. This discovery was not carried far regarding its value for immunity but was utilized as a test for the diagnosis of Kala azar, the chemotherapeutic measures with pentavalent antimony compounds being found to be more efficacious in reducing the incidence of the disease.

In amoebiasis too, it is found that although the symptoms could be quickly controlled by a few injections of emetine and some arsenical compounds, the ultimate eradication of the disease rests on the immunity of the person.

DR. DAS GUPTA said that as a result of investigations carried out with regard to the development of immunity in plasmodial infections, the conclusions arrived at by the speaker were as follows:—

Tolerance to reinfection with the same strain of P. Knowlesi in rhesus monkeys may be developed by repeated inoculations of the parasite combined with inadequate treatment. It (tolerance) depends upon the existence of scanty parasites in the body of the monkey ; when the infection is entirely got rid of the animal becomes quite as susceptible as an untreated subject.

From analogy it is not unreasonable to suppose that in the case of human plasmodial infections acquirement of protection against further infection is associated with the presence of the parasite in the body of the individual. And when the infection dies out tolerance to reinfection also disappears, thus showing the temporary protection acquired is far from being true immunity.

DR. CHATTERJEE raised the question of the relation between protozoal infection and its antagonism to various other infections. There is the wellknown immunity of Malaria and certain forms of nerve-syphilis. Whether a similar relation exists between Malaria and Plague which is conspicuous by its absence in Bengal and which is prevalent in other parts of India in cold and dry months of the year when the mosquitoes get the least chance to grow.

The speaker also referred to a very neglected subject, that is, the role of red cells in the production of immunity especially in Malaria.

He also raised the question of the source of globulins that are increased in Kala azar and other conditions.

DR. DUTTA observed that :

1. A point has been raised that malaria can be easily treated in England and not in India. In veterinary practice a similar condition is found at the Imperial Veterinary Research Institute, i.e. Babesiasis in cattle can easily be treated in the plains by means of Trypan blue whereas at Mukteswar the same infection does not respond to Trypan blue and other Chemotherapeutic agents have to be resorted to. This drug-fastness may probably be one of the factors in the case of Malaria in India.

2. In Veterinary Practice Protozoa do not appear to give rise to the production of anti-bodies in the animal system to an extent which would enable the use of serum for prophylactic purposes with so great a success as one finds in bacterial and virus diseases, though enough anti-bodies do develop which can be easily detected by means of serological tests. The latter fact is made use of in the diagnosis of various protozoon diseases especially Dourine in equines. Experiments have been carried out at

Mukteswar to prepare an anti-serum against Bovine Theilericasis but the results were not very encouraging as to put this product on the list of saleable biological products at Mukteswar.

3. In equine trypanosomiasis the use of Bayer 205 alone or in combination with Tartar Emetic overcomes the infection on account of the chemical action of the drug on the parasite but again the dead parasites act as antigen and produce active immunity.

4. Acidophilus cultures (long life bacillus) are made use of in avian coccidiosis. It lowers the *p*H of the intestinal tract and the increased acidity keeps the coccidia under check.

5. In Babesiasis in cattle there is age resistance (resistant in young age) and in infected places the young cattle get the infection and overcome it and remain resistant for the rest of their lives. In this case there is a 'Carrier immunity'.

## XIV. NUTRITIONAL DISEASES IN INDIA.

(*Section of Medical Research, in co-operation with the Society of Biological Chemists, India.*)

PROF. H. ELLIS C. WILSON, Calcutta, opened the discussion.

DR. PROBADH CH. DAS said that there are some manifestations during pregnancy such as stomatitis, gingivitis, ptyalism, pruritus, herpes zoster and cramps in legs, which were formerly classified as due to toxæmia of pregnancy have now been definitely proved to be due to deficiency of certain food products which are necessary for the maintenance of good health. He would like to ask Dr. Wilson if he has any experience about these diseases in India.

DR. HARDIKAR asked wherefrom the vegetarians get their different food factors, the deficiency of which gives rise to deficiency diseases and which it is suggested to make up by adding animal foods to the dietary.

DR. CHATTERJI said that height varies according to castes. Brahmins in general show a greater height than others and Moslems a shorter height. Sea board districts of Bengal show a shorter height and the northern districts a medium height. The districts with laterite soil show a shorter height. The average height is greater in Eastern Bengal than in Western Bengal.

DR. SEAL said that the point which he liked to stress is that apart from the clearly defined deficiency diseases there are, in India, many maladies which though not regarded as of malnutritional origin, should be considered to be due to a suboptional condition of nutrition. This subclinical state of deficiency is the primary cause of general ill-health and lowering of resistance of the various races and nationalities represented in India and is indirectly responsible for the most severe ravages of the country by variety of diseases such as malaria, kala azar, tuberculosis, leprosy, cholera, gastro-intestinal disorders, anæmias, diabetes, dysenteries, etc. The possible relationship of tuberculosis, leprosy, epidemic dropsy, respiratory diseases, and gastro-intestinal disorders, e.g. diarrhœa, dysentery, cholera, peptic ulcers, to dietetic deficiency may be very well represented. It may also be suggested that the incidence of other general diseases such as Malaria, Kala azar, etc. is to a certain extent dependent upon the nutritive factor as well. The solution of the problem of prevention of diseases in India is therefore one of improvement of conditions of living as of food supply of the people by improvement in the methods of

agriculture, animal husbandry and industry and lastly by restraint on reproduction.

DR. CHARUBRATA ROY said that a type of cases are seen which seem to be due to deficiency of vitamines. These cases come with jaundice, night blindness and marked pathological condition of cornea and the vision is much impaired.

On examination, the blood picture is that of anæmia with about 3 million R.B.C. and 45 to 50% of Hæmoglobin (6·3 to 7 gms. of Hb) Van den Bergh's reaction is positive both direct and indirect but the bilirubin content is not very high—3 or 4 units only. The R.B.C. in this case instead of showing more fragility than normal as one would expect in cases of jaundice were less fragile than normal (Hæmolysis taking place with 0·16% Nacl).

Administration of Cod Liver Oil did remarkable good to these cases. In course of 15 days, the whole picture changed and they got cured, in a very short time.

DR. J. N. MAITRA observed that a villager after suffering from night blindness for over 2 months (after a cure of Kala azar and Malaria) was put on an improved diet of milk and fish for 10 days and he left Calcutta cured.

## XV. THE PRACTICAL POSSIBILITY OF BREEDING IMMUNE STRAINS OF DOMESTICATED LIVE-STOCK.

(*Section of Veterinary Research.*)

[No report of the discussions has been received.]

## XVI. PHYSIOLOGY OF THE INDIVIDUAL IN HEALTH AND DISEASE.

(*Section of Physiology.*)

In the absence of the President Col. R. N. Chopra, Prof. Winifred Cullis of London, took the chair.

1. DR. B. MUKERJI (All-India Institute of Hygiene) opened the discussion.

The term Health has never been defined adequately as it is such a variable quantity. It is not merely a *negation of illness* as is generally believed, but also *means something positive.* The full use and control of the mental and physical functions, a vigorous constitution and bodily well-being are the characteristics of a healthy man and these would require the correct and normal functioning of the different parts of which the individual is composed.

Man, in a great many vital functions are actively and quickly responsive to the influences of physical environment. Body growth, speed of development, vigour and energy level, resistance to infection, and many other of his functions are dominated by the stimulating character of the climatic environment.

Climate consists of a large number of components, like temperature, wind, sunshine, seasons, moisture, storms, etc., of which medical science

still knows very little, although it is probably one of the most important factors in the life of man. Climate has a direct effect upon health and an indirect effect through food, incidence of disease and mode of life. Huntington in his book on 'Civilization and climate' endeavours to show that all the progressive races, which are distinguished by high energy level, civilization, and achievement in practical, scientific and intellectual spheres, live in particular types of climates which are characterized by their variability and their comparatively low mean temperatures. He contends that the old civilizations actually existed in such climates and that the decay of these civilizations was due to a gradual change of the climate to an equable or sub-tropical nature. In olden times the optimum climate was almost certainly further south than it is at the present time, and the view that Arabia, Syria and Mesopotamia once possessed a climate differing considerably from that of today is rapidly becoming accepted. Although the mean temperature in those countries may have altered little, there is hardly any doubt that they had abundant rain two thousand years ago, as, though now desert, they were then richly fertile and able to support many millions of people. According to him, civilization and progress unquestionably influence health, and health has an effect on energy, but neither of them can conquer climate and it seems certain that climate, therefore, must influence civilization, health, energy, etc.

Huntington's claims are not entirely fanciful and theoretical. Evidences of a biological nature are now accumulating, in increasing proportions, which point unmistakeably to the deductions made by Huntington on geographical and other grounds. Amongst the most fundamental of the indices of individual or mass welfare are those of growth and development. Incidental disease usually acts to depress these indices, but probably of greater importance is the increased susceptibility to disease that come with suppression of growth through such factors as deficient diet, lack of sunlight or debilitating climate. It had been recorded from extensive statistical studies that the growth in both height and weight of children is rapid in northern U.S.A. and North Central Europe, and drops sharply in the case of children in Italy, still more so in the Philippines and in Japan. These differences would at once raise the question for many people as to the racial differences in body-build, but they also raise the question whether such racial differences may not be basically those of diet or climate acting through the centuries. It is a well-known fact that Japanese, Philippinos, or Italians brought up in the climate of the northern United States showed a stature and body weight distinctly superior to those of the people remaining in their homeland. This improvement has been attributed by one group of workers to better economic status, and more ample diet. But apparently this explanation cannot be considered completely adequate. Studies on the growth of laboratory animals under well controlled conditions have shown clearly the climatic dominance over growth even when the diet was entirely adequate and held constant for all experimental groups. At least a presumptive basis was thus afforded for the belief that the slower body development in Indian children might also be due to the depressing moist heat of this conntry, and not primarily to a dietary deficiency.

Then again, there are definite evidence of physical deterioration in the tropical climate. From extensive statistical analysis of life expectancy, it has been shown that the majority of the tropical inhabitants reach old age when Europeans have barely attained middle age. In England, presbyopia due to progressive weakening of internal eye muscles becomes manifest at the age of forty-five and even later, whereas among the tropical races it comes on at about the age of thirty-five and even earlier. The same is true of senile cataract (a degenerative change in the lens of the eye causing opacity), which occurs more frequently and develops earlier in those people who inhabit hot countries. In the United States, factory statistics prove that in the south the power of sustained energy is lower than in the superior climate of the north; and also that the power of mental

and physical energy of those immigrants, and their descendants, who have come from an inferior climate, although improved, remains lower than that of peoples who have immigrated from a superior climate.

These evidences, taken together with the observations made by the learned president in his 'Presidential Address', leave little room for doubt that climate exerts a definite effect on the physical and physiological mechanisms of the body. The tropical individual is exposed to climatic changes which are different from those affecting the inhabitants of the temperate climes and hence the physiology of these two groups of individuals may be different. This viewpoint is important in the treatment of disease. Unless the normals are known for tropical people, the interpretation of many biophysical and biochemical alterations in the body fluids in different diseases will be subject to serious fallacy.

2. Dr. B. B. Dikshit (Haffkine Institute) said that there is reason to believe that there is a certain amount of change in the physiology of the individual in disease. This is illustrated by the fact that the physiological action of some drugs like the antipyretics is different in health and disease. His own observations on the choline esterase content of blood in toxæmia have shown that in toxæmia such as induced by plague infection (*B. pestis*), there is a marked reduction in choline esterase values of animals. These values come back to normal after natural or artificial recovery. As choline esterase is concerned in regulating the action of acetyl choline and as acetyl choline is so very important in regulating the physiological activities of the body, the reduction in choline esterase values of blood in disease is significant.

3. Mr. N. K. Iyengar (Institute of Hygiene) suggested that a study of the *in vitro* action of choline esterase on suspensions of *B. pestis* or in similar types of toxæmia should be done with a view to ascertain how this process of detoxification takes place through choline esterase. This will throw light on Dr. Dikshit's observations on the diminution of cholene esterase content of blood in toxæmic processes.

4. Prof. W. Straub (Munich) remarked that the range of physiological activity is within wide limits and the body can gradually adjust itself to changed conditions which in ordinary circumstances would prove fatal. Those who are accustomed to taking beetle nut in India, habitually take an amount of arecoline which will prove highly injurious or even fatal to those who are not at all accustomed to it. He further remarked that climate must have an important part to play in both physiological and pathological conditions. The Englishman, for example, always take tea as their beverage and the Arabs, Coffee. This has been usually explained on the easy availability of each beverage in the respective places. While working on the pharmacology of these drugs particularly with reference to their metabolism and excretion, he found that coffee is easily broken down in the system and is rapidly excreted, whereas tea stays for a longer period in the system and takes a longer time to be excreted. The habit of the Englishman in sticking to tea instead of adopting coffee, is probably due to this knowledge instinctively gained. The cold climate in England possibly demands a longer stimulation which naturally is not needed in Arabia.

5. Dr. Mir Mansur Ali (Institute of Hygiene) remarked that it will be of great advantage if this aspect of physiology was given more attention to.

6. Dr. B. B. Sarkar (Calcutta University) pointed out that man is dependent for his very existence on his power of adaptation to the environmental changes, not only external to his body but also internal, i.e., the environment of his body cells. His two sets of regulators—the nervous system with the receptors and the endocrine system help him to adjust himself to new conditions. In disease the body tries to adjust itself to the

changed conditions, to which the system of the individual has been exposed, so as to carry on the physiological process. Pathology can thus be described as abnormal physiology or the physiology of disease.

7. DR. E. P. POULTON (London) reminded the audience that the physiological standards vary in different conditions. The average weight for height standard which is taken as normal in the case of persons above fifty, even by the Insurance Companies is not correct. It has been found by statistical analysis that persons whose weight for height values at this age are below this average figure, live longer than person whose values confirm to this average or is higher.

8 DR. K. VENKATACHALAM (Madras) remarked that the definition of a physiological constant is difficult to give, as the human system is constantly adjusting itself to environmental changes. He gave evidences of various diseases where a distinct predilection to climate was noticed. Angina pectoris, hypertension, diabetes, nephritis, leprosy, etc. have been definitely shown to be predicated by climatic changes. Certain diseases occur more frequently in a cold climate and during the winter while other diseases are definitely more prominent during the summer and hot climates.

## XVII. DIET AND ADAPTATION TO CLIMATE.

*(Section of Physiology, in co-operation with the Society of Biological Chemists, India.)*

1. PROF. H. ELLIS C. WILSON, Calcutta, opened the discussion.

The question of diet and adaptation might be looked at in two ways. Did a man adapt his diet to the environment, or in how far was food in any particular region of the world suited to man's needs?

Buckle in his 'History of Civilization' written nearly 100 years ago pointed out that Nature provided fat which had a high energy value in the Polar regions and starchy foods at the Equator. This viewpoint appears now to be borne out by recent experimental data. Foods rich in starchy material tended to keep the body more saturated with a reserve of mobile fluid which was evaporated from the skin and helped to keep the body cool in a tropical climate. The two cereals, rice and wheat or atta, offered a somewhat similar picture. Wheat was consumed in the temperate and sub-tropical regions and rice in the tropics. Investigations in the human subject had shown that rice, in contrast to 'atta' (wheat flour), provided the body with a greater reserve of mobile fluid both for evaporation from the skin and excretion by the kidney. Further, rice contained somewhat less minerals than 'atta'. These two properties probably rendered those who consumed rice less liable to deposit stone in the bladder than those who ate wheat. It was well known that this condition was commoner in the Punjab where 'atta' was the staple cereal, than in Bengal.

These few observations would tend to rescue rice and its unpleasant associations with beriberi and possibly epidemic dropsy from the *harijan* (untouchable) position it tended to hold in cereal society.

2. DR. B. C. GUHA (University College of Science) remarked that in determining the quantity of protein that should be consumed in the tropics, the specific dynamic action of protein should be considered. In a tropical country it would seem, from a *priori* consideration, that the quantity of protein required for optimum nutrition may be less than that required in temperate climates. It should be emphasized, however, that the consumption of protein of higher biological value should be encouraged.

As regards iron, it has been found that the daily intake of ionisable iron per head by the students residing in the college hostels in Calcutta varies between 4 mg. to 7 mg. which seems to be slightly lower than the optimum quantity which has been recommended. As regards vitamin C, considering the lower basal metabolism in India, it is probable that a smaller quantity of vitamin C, may be necessary in India than in colder climates. It is difficult to give any authoritative opinion on these findings at present. When nutritional standards for India are determined many such problems will be clarified.

3. Prof. N. M. Basu (Presidency College) remarked that the quantity of protein that is taken in some parts of India is indeed low, for Beharees and people of U.P. are mostly vegetarians. But the curious fact is that labourers in Calcutta, who possess very good physique and are indefatigable workers, are mostly people recruited from those provinces. How are we to explain this? Is it then possible that essential amino-acids are formed in their bodies. This being the case, the biological value of proteins should not be given so much stress, as is done. Berg also raised similar questions in Germany. He has shown that the amount of protein taken may be reduced to a considerable extent, if the acid-base balance in the food is maintained and if the person is accustomed to a low protein diet.

4. Dr. H. N. Chatterjee (Carmichael Medical College) remarked that hæmotological findings carried out by himself showed definite abnormal values in females, specially in mothers. The number of anæmia cases were remarkably more numerous in females than in males. Possibly this might be due to their food habits as it is the custom of the Hindu housewife to take her meals after the other members of her household have fed, and it is not unlikely that the women folks actually get less nutritious material from the already poor daily diet of an average Bengalee household.

5. Dr. S. N. Roy (Carmichæl Medical College) remarked that an increased carbohydrate uptake will induce a greater output of water both by the kidneys as well as by the skin, resulting in the greater washing out of the body tissues and depletion of soluble mineral salts. As Indian dietaries are deficient in many mineral salts specially calcium, this greater output of water by the body may be harmful. This lower intake and greater outflowing of calcium from the system may explain the shorter stature of rice eating inhabitants of India.

6. Dr. J. G. Parekh (Bombay) remarked that it is generally agreed that the Basal metabolic rate is lower of the Indians as compared with the Western Standard. He has further observed that vegetarians have a lower Basal metabolic rate on an average about 3% lower than those who take meat diet. The majority of Indians are vegetarians and this vegetarianism is perhaps physiological and an adaptive mechanism to the demands of a tropical climate.

7. Dr. B. B. Sarkar pointed out that in a particular locality, inhabitants apparently have, from long experience extending over generations, evolved a dietary suitable for the particular conditions of temperature, climate, humidity, available food materials, etc. of the country. This dietary history of the people has an important bearing on their nutrition but unfortunately this aspect of the question has not, as yet, received the proper attention of physiologists. Classes of people accustomed to take high carbohydrate diet for generations have a different nutritional history from the classes of people who have been living on a high protein diet. The dietary habits of the people should be taken into consideration when devising their diets.

8. Dr. B. Mukerji remarked that Dr. Wilson has referred to the superior water-binding power of the carbohydrates and the role it plays in water metabolism and water exchange from the body. In this con-

nection he would like to enquire whether there was any difference between the water-retaining capacity of 'rice' and 'atta'. Rice is the staple diet in Central and South India whereas 'atta' is the important food in the Northern parts. Whether this habit of rice eating in certain parts of India and 'atta' eating in other parts have anything to do with heat regulation phenomena? The humid heat of Central and Southern India would exert a severer strain on the phenomena of water exchange.

9. DR. B. NARAYANA (Patna) remarked that heredity may play an important part in the health of an individual living on a particular diet. There are families who have been vegetarians for generations and who have been living on very low protein diet and that too of low biological value, are keeping good health and living to a good old age. It is necessary that statistical observations be made on the subject with a view to finding out if heredity at all is responsible for adaptation to a particular diet.

10. DR. YODH (Bombay) pointed out the importance of the economic factor in the study of diet.

11. DR. D. MITTER (Institute of Hygiene) remarked that for supplying biologically complete proteins to the poorer masses in India, it would appear that one should aim at supplying more varied proteins through vegetable sources supplemented with a little milk or egg, because it is found that absorption of protein takes place better at basal levels.

12. DR. U. BASU (Calcutta) said that to maintain the Normal Hæmoglobin level in infants they should be given 'Palo' (*curcuma zeodoria*) as this cereal is rich in iron.

13. DR. MIR MANSUR ALI remarked that in diet and nutrition apart from environmental factor, the psychological factor cannot be ignored. It has been observed that students living under the same environmental conditions and taking the same food, have different nutrition standards in health. This may be due to the suitability of a particular type of food to the fancy of a particular group of students. This 'liking' factor probably operates through the digestive system and selective absorption.

14. DR. NEIL EDWARDS (Institute of Hygiene) suggested that the low figures for Hæmoglobin which has been observed by some workers in Indian women may be due to the fact that those cases were not in good health and that pregnancy and lactation may have unfavourably affected the findings. In a small series of hæmatological studies carried out on healthy young women (buoyantly healthy) in Calcutta, the findings compared favourably with the standards mentioned in the literature for British women. There does not seem therefore to have a great difference between the blood picture of women in the two countries. Before pronouncing any opinion on minute differences, the factors due to disease, etc. should be completely eliminated.

## XVIII. CONTRIBUTIONS OF ABNORMAL PSYCHOLOGY TO NORMAL PSYCHOLOGY.

(*Section of Psychology.*)

DR. G. BOSE presided.

1. DR. S. C. MITRA, Calcutta.

Various factors contributed to the rise of modern psychology towards the end of the last century. Since the establishment by Wundt of the

first Laboratory in the University of Leipzig, psychology has been making steady progress. Of all the events in the world of thought that have influenced the course of the psychological science the rise and progress of abnormal psychology has been the most outstanding one and the most effective. Psycho-analysis is the most comprehensive of all the prevailing schools of abnormal psychology.

Behaviourism and psychology have entirely different universes of discourse. Therefore the former is constitutionally unable to take the place of the latter. Behaviourism cannot properly be considered as a mental science. There is an absence of dynamic principle in 'existentialism'. The principles of 'existential' school lead to pure abstractions which bear no contact with the realities of life. The methods of mental measurement are sometimes able to render practical help in certain concrete situations of life, but they are no guide to the understanding of the intricate problems of mind. The principles of Gestalt psychology give a good phenomenological description of mental states and functions. But personal subjective experiences are characterized by a peculiar feeling of intimacy and therefore we cannot remain satisfied with merely phenomenological descriptions.

Psycho-analysis gives us not only a better and more thorough explanation of each of the psychological phenomena traditionally treated in the text-books, but also of other normal psychical experiences usually neglected in them. In addition it supplies us with a method by following which we are enabled to reach the innermost core of a person's psyche. The objection that the conclusions of psycho-analysis are based on observation of abnormal mind and therefore are inapplicable to the processes of normal minds, does not hold. There is a continuous gradation between accepted normality and proved abnormality and the only criterion of normality that we can adopt is what Bose has laid down, viz., harmony with the social standard of the place and with the time. It is legitimate to assume that the principles governing the inner mechanism of all minds are the same every where and whether the manifestations of a particular one should be dubbed normal or abnormal would depend purely on external considerations, viz., the social standard.

Psycho-analysis has widely extended the borders of psychology by revealing regions of the mind hitherto not traversed or not thought fit to be traced. Dreams, misplacing of objects, forgetting of names and hundred other similar occurrences, are normal psychological phenomena, but in pre-analytical days they were not given their dues in the text-books. Psycho-analysis has given precise definitions of the terms unconscious, subconscious, etc. It has demonstrated the immense influence that the Unconscious exerts on all psychological experiences. It has made significant contribution in the sphere of memory. One of its conclusions regarding the influence of the Unconscious has been experimentally and verified by Maiti in the Laboratory of Calcutta. Bose's theory of action-attitude gives a better explanation of illusions. Another great achievement of psycho-analysis lies in the domain of feelings and emotions. The ambivalence of feelings, the ways of transformations of emotions, the complexes, and conflicts and their influence on the development of personality, the rôle of emotions in the early life of the child are but some of the most important contributions that have been made by psycho-analysis to psychology. In spite of the protestations of many the discovery of the sex instinct and of sex emotions in children by which is meant not only the presence of these in the children, but their gradual development through the various stages, beginning from the polymorphous perverse stage in infants to the normal heterosexual stage in the adults is one of the highest achievements in the study of man's mind and is bound to be recognized sooner or later as one of the greatest discoveries of the age. This discovery has entirely changed the outlook of the teachers and educators all the world over regarding the ideas and methods of their noble mission.

Psycho-analytical studies of affections and emotions have helped to elucidate more clearly and systematically our appreciation and creation of all fine arts and literature.

Not only actions of particular individuals but those of collective groups also are more fully expounded now on the psycho-analytical principles. While anthropology and sociology, history and even politics are imbued now with the spirit of the new investigations, the studies of customs and traditions, morality and religion have been given a fresh impetus and a new orientation to the advantage of all concerned. To take only two illustrations : Freud's explanations of the influence of the mob and the group and his theory of the development of the super-ego, popularly called conscience, remain unsurpassed as pieces of deep psychological analysis and close systematic thinking.

Only general outlines of the contributions of psycho-analysis to normal psychology have been given in this paper. The virtues of perfection and completeness for psycho-analysis are not claimed. But it can safely be said that psycho-analysis has not only enriched both in quality and in quantity every topic of normal psychology but enlivened the whole science itself so that the latter pulsates now with the new vigour and boldly attacks the problems of life that only the other day it made it a point to evade. And for this metamorphosis of psychology credit must needs go to Freud's discovery of the Unconscious, which event has consequently been very justly listed with the Copernican discovery and the Darwinian theory as the third landmark in the way of progress of the sciences.

2. Lt.-Col. Owen Berkeley-Hill, Ranchi.

The criterion of normality referred to in the above paper is not accepted. The term 'normal' has two meanings.—First it may mean 'the most usual' or the 'average'. In other words 'normal' in this sense has a 'statistical' connotation. On the other hand 'normal' may be made to mean the 'healthy' as opposed to the 'diseased', in which case it has an 'evaluative' connotation. Most of us tend to confuse these two meanings, because our ideas of what is 'good' or 'healthy' are largely determined by what is most prevalent although not always consistently because there are qualities, e.g. abilities which we admire when present in an unusual degree. We may ask ourselves therefore how far we should allow our view as to what constitutes 'normal' or 'abnormal' psychology to be influenced by what, on the one hand, is evaluatively normal and by what, on the other hand, is statistically normal. This difficulty which is not a small one, will be got over as soon as we talk of psychology and make no distinction between the normal and abnormal psychology. Under such conditions the title of the symposium would have been 'The Debt of Psychology to Psychotherapy'.

3. Mr. H. D. Bhattacharyya, Dacca.

At bottom the question of normality is intimately bound up with the question of social existence. No wonder that the study of the social mind should acquire increasing importance with the development of the study of abnormal mind. Academic psychology ignored both the depth and extent of the human mind. The concept of epigenesis or creative synthesis tried to supply the element of unity and organization, but did not succeed.

Functionalism also did not improve matters. In one word, academic psychology suffered more or less from the tyranny of generalization and abstraction and it neglected the special constituents of individual minds and their historical growth in reaction to definite environmental conditions.

The rise of individual psychology is coeval with the development of abnormal psychology. The personal individual is not exactly a representative of his class in the same sense in which one inorganic substance can

take the place of another belonging to the same class. Each case therefore must be studied in his historical growth and must form the subject-matter of individual attention, analysis and treatment. To ignore the historical setting of a given conduct is to obliterate the distinction between the inorganic and organic and to deny as Bergson effectively and eloquently preaches, the reality of time.

The discovery of the individual has been accompanied by the finding that without reference to the social milieu the growth of individuality cannot be understood at all. Abnormal psychology has been mainly instrumental in drawing attention to the great part played by society in moulding the development of the individual minds. To the lasting credit of abnormal psychology be it said that it has shown most effectively the result of conflict between personal desires and social requirements. It has been able to demonstrate that unsocial tendencies that do not succeed in getting an expression managed to survive in the cavern of the mind and even sally forth on occasions in disguised forms and produce psychopathologies of daily life like forgetfulness of names and things, psychogenic falsities like hallucinations, illusions and dreams, veiled obscenities like smutty jokes, pornographic tales, sensual emblems in art and religion and also unaccountable humours and sudden conversions. It has familiarized us to the facts of dissociations of personality. The successful attempt of psychologists to reintegrate the dissociated strands of personality and to restore the normal reaction to society must be accepted as the virtual verification of their hypothesis regarding the mind and its workings. Even with the best of intentions a man cannot fathom the depths of his own soul by mere introspection, for much of what passes for rational thinking is at bottom rationalization and what apparently passes for a true motive of action may be only a cloak for some deeper lying intention of which the conscious mind is not aware at all. So the definition of man as a rational animal should not be understood in the sense that man is rational at all times or that he knows the reasons of his conscious states in all cases or, in fact, in any case. He is a creature of impulses and desires and his normal and morbid reactions are all prompted by the inner urges—many of libidinous character and all designed to fulfil this or that wish of a conscious or unconscious kind. A presumption is raised that there is such a thing as the rational unconscious and the existence of typical symbols in dreams serves to indicate that some common factor activates thinking in slumber.

Abnormal psychology has established the fact that mind attempts at all times to effect an adjustment to given situations. Compromise is writ large across the face of the mind. To avoid coming into constant conflict with society the individual develops the super-ego and thus sets up a miniature machinary within itself to curb the insistent urges of the antisocial id from below the levels of consciousness. In between the super-ego and the id lies the ego—the life of consciousness and compromise. Abnormal psychology has also made valuable contributions towards an understanding of crowd leadership, religious devotion, social taboo and totem and kindred phenomena of the individual and social mind. The greatest contributions of abnormal psychology are two, viz., that the self is a unity in diversity (mimicking in this respect the relationship of the Absolute and the finite selves) and that identical principles operates in different fields of mental activity, individual and social.

4. Mr. Jamuna Prosad, Patna.

One cannot but agree with the general theme of the leading article, but there is an obvious one-sidedness in the discourse. In it normal psychology is altogether denounced as stale, incompetent, and useless. But it should be pointed out that many valuable facts and principles about psychological topics, e.g. about emotion, were known to normal psychology independently of the finding of the abnormal. There are other

schools of abnormal psychology besides psycho-analysis which have not been even referred to. Jung's word association experiment, Adler's observations on 'Inferiority Complex', the works of Janet and Prince on dissociation have been neglected. Secondly no science should have a craving for popular approval, a craze for 'blazing forth before the admiring gaze of the public'. Even psycho-analysis does not care for the blessings of the man in the street nor for the 'good sense and fine feelings' of the elite. Thirdly while it may be admitted that the traditional existential and academic psychology are a failure, the dynamic and functional schools have undeniably contributed towards our understanding of the human nature in the various aspects. On the other hand the success of psycho-analysis in solving the mysteries of the human nature may very well be doubted. Even in regard to the problem of neurosis it is believed by many psycho-analysts themselves 'that psycho-analysis has no answer as to the fundamental basis of the development of neurosis'. In regard to anxiety as the basis of neurosis Freud has openly admitted in his *New Introductory Lectures on Psycho-analysis* 'that everything here is in a state of flux'.

It is unhesitatingly affirmed in the leading article that the highest achievement of psycho-analysis is the discovery of the infantile sexuality and of the stages of growth from the 'polymorphous perverse' to the normal hetero-sexual stage. General psychology, however, has not accepted the whole story as true, rather it has strongly repudiated the suggestion that the child is nothing but sexuality incarnate. Stern, a recognized authority on the Child Psychology, points out that the belief in the sexuality of infants is a curious instance of 'reversed' projection from the so-called reminiscences of adult neurotics. It is only the psycho-analytical child psychologists, e.g. Anna Freud, Melanie Klein, etc. who are convinced of the sexuality of infants. The grotesque phrase 'polymorphous perverse' is inapplicable to the child and betrays a serious lack of understanding of the child mind. All the evidence regarding infantile sexuality is based on data, rather of the selected type. The so-called reminiscences of the adult neurotics on which the whole theory of the infantile sexuality is based, have in most cases, proved to be mere fantasies and justifications of the patients' special attitude in the psycho-analysts' consulting room.

As regards the contributions of psycho-analysis a division should be made between (1) those which are of real value to general psychology and have been more or less definitely adopted by it, and (2) those which are of doubtful value to it and remain confined to psychoanalytic works as characteristically distinctive of their special creed, marred by exaggeration and even lacking in evidence.

In some important respects psycho-analysis has done a positive disservice to psychology. Its mechanistic conception of mind, and its erroneous genetic principles are instances. Justice has not been done to the developmental impulse which actuates man's life ever since the foundations of its birth are laid, and which is perpetually expressed in his longing to be more than what he finds himself to be. As a result we get a curiously inverted view, viz., the test of the normal lies in the abnormal and that normality is repressed abnormality. But credit must be given to Freud for recognizing recently, this much at least, that the Oedipus Complex has passed away and does not exist in the normals, and greater credit still for his more recent assertion even in regard to the neurotics, that we shall have to abandon the universality of the dictum that the 'Oedipus Complex is the nucleus of the neurosis'.

The unnecessary laziness and even lack of willingness of normal psychology to assimilate many valuable contribution of abnormal psychology are to be admitted. But probably there is some real difficulty in the task of assimilation on account of the new concepts and terms of abnormal psychology, which somehow remain alien to and refuse to fall easily in line with those of normal psychology. Consequently it continues to remain typically the psychology of the conscious, unmindful of the

the risk of remaining distinctly poor for neglecting the unconscious. A constructive suggestion may be made. What we need is a seriously planned out scheme requiring the joint efforts of many to work together in close collaboration in order to evaluate and readopt the contributions, not of psycho-analysis alone, but of all schools of abnormal psychology, so that a new type of general psychology, having a close touch with the concrete problems of real life, may be produced, and we may advance towards a wider, deeper, and truer understanding of human nature.

5. DR. T. PURUSHOTTAM, Waltair.

The importance of the criticism levelled against Freudian and other psycho-analytical schools of psychology, viz., that they err in attempting to give us a picture of normal mind and its operations by attempting a reconstruction of that picture from the data obtained in the field of mental pathology or abnormality, should not be minimized. But it holds valid on the assumption that abnormal psychology adopted method which evolved in the consulting room of the physician. This assumption is untrue. The greatest discovery of Freud's lifetime is in the province of the psychology of the *Dreams*. His insight into the mechanisms of neuroses is but a logical development of his initial insight into the nature of the dream. The principles formulated therein are indispensable to a comprehension of mind as *MIND*. The scope of Freud's discoveries remains general, i.e. not restricted to the field of abnormality or pathology. Freud conceives the psychological individual in the light of strict determinism. Whatever the scientific value of such contributions to our understanding of Mind may be, it is obvious that in their relevancy and scope the ideas belong to normal psychology.

Before Freud, there has been no psychological objectivity worth mentioning. Psychology fails as a science because of lack of such objectivity. Objectivity in psychology is achieved only when the object of psychological study is grasped not as a robot or a vegetable or an instinct-ridden psychophysical organism, but as the living mind—what lives on more than food, what shapes and uses the instruments of its action, and grasps all things and worlds for the sweetnesses thereof.

That the energy of the living mind is libidinal is one observation of Freud that will remain unsurpassed for its acuteness for well over a century to come. We live in times to near the event. It is pardonable if we don't realize the entire scope of that great observation. May be, Freud himself does not realize it. It is an observation of genius. Its confirmation will have to be found along every avenue of approach to truth concerning the living mind, whether it is manifested in the deep sea, or in the birds of the air or in man, individual or collective. Such confirmation is already forthcoming.

The principle of libido takes priority over even vital process, and thus proposes a psychological foundation for, and bestows a psychological character upon, phenomena which we are normally inclined to regard as a-psychic, i.e. biochemical, physiological, evolutionary, vital, etc. It is highly significant that even in sexually differentiated organism, libidinal manifestations precedes in ontogeny (and probably too in phylogeny) the development of sexual apparatuses. Libido is a wider conception than Sex. It is the fundamental attribute of all life as the Joy that breaks into living forms.

The terms 'conflict', 'repression', 'resistance', 'dissociation', 'fixation', 'regression', etc. have thrown light on many biological phenomena and profoundly influenced the scientific thought. Psychology can ill-afford to let sister sciences profit out of its own wealth, itself remaining callous to its vast treasure.

Maranon presents data which force on us the conviction that individual bisexuality is normal feature of individual existence.

The co-ordination of the discoveries of Maranon with the doctrines of the Freudian psychology is a piece of work yet to be accomplished. It is one which devolves upon the psychologists of our own generation.

While general psychology appears to be slow to plumb the depths of the individual 'psyche', sister sciences are marching forward developing the concept and enriching its content. Erich Wittkower addressing the Psychiatric section of the British Medical Association, demands a psychological foundation for scientific pharmacopœia and medicine.

Let it be reiterated that the proper object of psychological study is the psyche and that the facts of abnormal mental life, as well as those of normality, have forced upon us anew the importance of recognizing the reality and pervasiveness of the thinking 'thing', 'res cogitans' of Des Cartes.

> 'Mano mayah prana sareera nata,
> Pratishtitho(a)nne hridayam sannidhaya.'

It is to be wondered whether normal psychology in all its extent and applications can hope to find a more appropriate object for its contemplation.

6. Dr. J. K. Sarkar, Muzaffarpur.

Psycho-analysis has thrown much light upon the intricate problems or the obscurer phenomena of thought, feeling and behaviour. But behaviour is many sided. No single branch of psychology can take charge of the human behaviour in entirety. Behaviourism maintains a thorough going legitimate, scientific attitude. Its studies of conditioned reflexes and glandular secretions are significant but its fallacy lies in taking motor and glandular responses as ultimate. Existentialism is a pure science and as such should be distinguished from psychology as an applied science Test psychology is also purely scientific and experimental. So also is Gestalt Psychology. According to Collins and Drever a psychology which is not experimental is to-day an anachronism in any department of mental life. While some experimental works have been done in the fields of word association and aberrant behaviour, the difficulties that are met in the application of experimental method to psycho-analysis are very great indeed. In view of the vast benefit that psychology would be likely to derive, if psycho-analysis could be made amenable to experimental technique, the attempt seems emphatically to be worth the making. Detailed analysis of conscious sense perception shows that the unconscious lies at the core of all conscious processes. That *it itself* is the foundation on which normal psychology stands, is the greatest contribution made by abnormal psychology to the former.

7. Mr. H. P. Maiti, Calcutta.

The choice of the subject-matter of the present symposium is very appropriate. It focusses our critical attention to the important problem of the influence of psycho-analysis on psychology. Large number of psychologists in India are still very much 'academic'. The symposium may serve a valuable purpose by drawing their pointed attention to one of the outstanding aspects of modern psychology that appears to have given us a key to many mysteries of human nature. All the views expressed in the leading paper as also the total impression regarding the worthlessness of non-psychoanalytical psychology conveyed by that paper cannot be subscribed to. The metamorphosis of psycho-analysis to psychology is not an accomplished fact and is yet to come. Psycho-analysis is not the most comprehensive of all the prevailing schools of abnormal psychology. Psychiatric school lays claim to valuable contributions in addition to helping the growth of psycho-analysis itself. It has partly stimulated the development of mental tests and specially of personality tests.

All the schools of contemporary psychology, including the psycho-analytical, are partial in outlook. The leader of the symposium writing as a schoolman himself, has failed to give due weight to this fact in his summary criticism of the various schools. The particular aspect from which psycho-analysis studies life is that of the Unconscious. But it cannot or does not deny the value of the conscious aspect; for, it has not only to begin work of analysis, but also to carry it on, from the plane of consciousness. Psycho-analysis starts from from a sort of normal psychology, e.g. psychology of consciously motivated conduct; proceeds to an assumption of hypothetical motives in the case of apparently unmotivated behaviour; gathers support for this assumption from therapeutic success and wide range of applicability of its hypotheses; and finally comes to revise the normal psychology with which it began. The detailed explanation of the unconscious has added materially to our knowledge of the emotional life of man and the significance of the new knowledge for practical life is immense. But these contributions only supplement the phenomenal descriptions of the psychologists and the physiological findings of investigators like Cannon.

Psycho-analysis represents a partial outlook and approach like the other schools, but it cannot be denied that its significance for the future of psychology as well as of human life is much greater than that of any other contemporary school. It is better to remain eclectic in the present state of our science than to identify oneself with the psychoanalytic school.

As regards the positive contributions of psycho-analysis nothing need be added to what has been said in the leading paper. The discovery of the social implication of our behaviour, overt or implicit, is very significant. The Mental Hygiene Movement, the New education and many other such movements are based on the concept of the unconscious. The hypothesis of the unconscious therefore has a pragmatic superiority in comparison with the neurological one for psychological research.

There is need for contact and co-operation between psycho-analysis and psychology. Reactions of assimilation, specially from the side of normal psychology are already on the way, as will be evident from the text-books and histories of psychology recently published. But there are some difficulties to be overcome. The main difficulty is one of method. A scientist cannot be expected to accept a fact or theory relating to his science without verification for himself. Use of the clinical method in some form in the Laboratory would certainly help the reapproachment work to a great extent. With increase in the number of Normal Analysis it would be possible to have a sufficient number of Laboratory subjects, for a series of Free Association sittings to warrant generalisation about unconscious factors after the experimental ideal of Normal Psychologists.

The idea is current among some that as the clinical method works *en masse* on the personality and not any simple abstracted feature of it, it cannot be a scientific method. But the clinical method of psycho-analysis at least on its exploratory side is comparable in essentials to an accepted laboratory method. The similarity has been pointed out by the writer in a paper to be published shortly, dealing with the reaction time experiment.

The psycho-analytical terms and concepts appear to many to be cumbrous and substantive in import. Psychologists cannot be asked to reconcile themselves easily to believe in the mental substantive after their sustained labour for centuries to throw them out. We shall have in near future to attempt simplification of terms and concepts by symposium discussions or conferences but mostly by sympathetic understanding. Professional vanity would not surely stand in the way, for nothing appeals so much to the heart of the true scientist as pursuit of truth.

8. MR. M. N. BANERJI, Calcutta.

Psycho-analysis is not the whole of abnormal psychology nor a representative sample of the latter before the rise of the former. Psychi-

atry and the physiological lines of approach to abnormal mental phenomena and non-psychoanalytic psychological study of them have thrown floods of light on general principles of psychology. All mental states whether they are cognised in the normal or the abnormal mind are natural All laws worth the name should be able to explain mental phenomena irrespective of whether we label them normal or abnormal from socio-behaviouristic point. From the stand-point of pure psychology, there is no such thing as normal or abnormal, therefore no necessity arises to prove formally that certain laws discovered in connection with the working of the unsoucd mind are of general applicability. Psycho-analysis was essentially a free association method thrust on the master mind of Freud by his patients and first applied to cure Hysteria and other neurosis. Freud gave a new orientation to the term 'Unconscious' out of vague and loose nebulous conjectures. The scope of psychology along that of the mind was extended and we came face to face with the kernel of Mind and the forces that worked there, the basic innate urges of self and Sex instinct and the 'Id'.

Psycho-analysis is not abnormal psychology at all. It is pure and simple depth or dynamic psychology. It is not a viewpoint but an extensive addition to the scopo and method of psychology—pure and applied. What the Experimental Psychology of Wundtian school and its derivatives dealt with was only the conscious part of the mind and psycho-analysis deals with the unconscious portion. The two should be bridged as is being attempted in the Bengal school now under the President of this section.

Evaluation of contribution of other abnormal psychologists has been omitted in the leading paper. Wundtian Psychology and other schools based on it have not failed altogether. Their aim of psychology was not identical with the present day viewpoints of psychology. Behaviouristic school lays emphasis on the physiological explanation. Except psycho-analysis, Wundtian Experimental Psychology has done a great service. There is a very bright future for 'mental measurement' school. Gestalt psychologists by their new experiments on perception of movement and their emphasis on the whole have done real service.

9. DR. N. N. SEN-GUPTA, Lucknow.

Normal and abnormal psychology have been mutually influencing each other since a long time past. A survey of the process of interchange of concepts and insights between the fields of abnormal and general psychology shows that the former has influenced the latter in *six* principal ways: (1) It has drawn attention to several facts of normal psychology, e.g. dreams, day-dreams, etc. and has amplified the connotation of many others. (2) It has formulated certain interpretative concepts, e.g. the Unconscious, fore-conscious, Extroversion, Introversion, etc. (3) It has also formulated a number of relational concepts, e.g. condensation, Identification. etc. (4) Some new concepts have been introduced by it to normal psychology, e.g. the phenomena of suggestibility, attitude, disposition and others. (5) The Ego is defined in abnormal psychology in a more concrete setting than is common, e.g. in the schools of Wundt, James and others. Similarly the much misunderstood idea of Sex is better described in Freudian Psychology. (6) Lastly, abnormal psychology suggests a new method of approach to the psychological sciences. Psycho-analysis is the technique for the discovery of the phase of the total psychological patterns.

The methods of abnormal psychology are now fairly well-established. The mental states and behaviour of the abnormal are described in their phenomenal aspects. The phases of the total experience are observed and are so connected as to picture a unitary whole. This whole and its phases are correlated with: (1) the past experience, (2) the environment, (3) the physical condition. In the light of this knowledge the symptoms are explained and curative measures are devised.

The method of general psychology is conceived in a similar fashion. The mental processes and behaviour are determined by four sets of factors : (1) Antecedent conditions of the organism. Some of those are at time capable of discovery by self-observation ; other times they cannot be so discovered. (2) Bodily processes, including the hereditary trends, the character of the nervous system and the rest of the organs of the body. (3) Physical environment including (i) certain general factors such as altitude, climatic conditions, etc. and also (i) specific stimuli. (4) Social stimuli such as the number and nature of the social group.

10. Dr. S. C. Mitra, Calcutta.

*Reply to the above discussion.*

I am quite prepared to agree with Lt.-Col. Owen Berkeley-Hill, that taken in a very broad and general way there is no distinction between normal and abnormal psychology, because whatever happens mentally either in the sphere of what is regarded as normal or in the sphere of what is distinguished as abnormal is perfectly 'normal' in the sense of 'natural' event as under the circumstances nothing else could have happened. Had we lived only in the high intellectual sphere of pure abstractions and wide generalizations without the necessity of having any practical contact with our fellow beings there would have been no need to make any distinction between normal and abnormal, or for the matter of that between physics and chemistry, between plant and animals. But we live in a society and society makes incessant and multifarious demands on us. Unless we can meet these demands and adjust ourselves to the situation, we are sure to be driven to the wall. Useful modes of adjustment to particular situations soon develop and they become the standards of conduct. They come to be regarded as normal forms of behaviour. Anxiety is a normal psychological phenomenon, but it becomes abnormal only when it is out of proportion to the situation, i.e., when it leads to maladjusted behaviours. The primary necessity which urged us to make a distinction between normal and abnormal arose from our attempts at adjustment to social demands. So that the statistical-social seems to me to be the only acceptable sense of the term 'normal' which can be profitably pursued in psychology. Besides, how is the province of psycho-therapy to which Col. Berkeley-Hill refers, to be defined and what is health and what is disease ? Proper definition of these terms would inevitably lead to the concepts of adjustment and maladjustment.

I am glad to find myself in a position to accept all that has been said by Prof. H. D. Bhattacharyya, and would like to draw attention to the special emphasis that he has laid on the influence of the social environment on the development of individual behaviours, normal or abnormal. In drawing the distinction between normal and abnormal, he recognizes the social standard. He accepts that man is a creature of impulses and desires and that the normal and morbid reactions of men are all prompted by inner urges—many of libidinous character and all designed to fulfil this or that wish of a conscious or unconscious kind. He has no doubt about the importance of the contributions that have been made by abnormal psychology towards the understanding of crowd leadership, religious devotion, sociological phenomena of different kinds and kindred products of the individual and social mind. He has hinted at a probable philosophical background of the discoveries of the abnormal psychology.

Prof. Jamuna Prosad points out that all the schools of psychology to which I have referred, have made valuable contributions independently of the findings of abnormal psychology and takes me to task for denouncing all these schools and for my failure to consider the researches of Jung and Adler. The introductory portion of my address will convince anyone that it was far from my intention to denounce wholly every prevailing school of psychology. I have merely attempted to point out what appears

to me the shortcoming of these schools and I am sorry if it has created the impression of an out and out denunciation. I have not specially mentioned the researches of Jung and Adler not because I do not consider them valueless but simply because what is valuable in them has been incorporated in the Freudian system. Prof. J. Prosad seems to be very doubtful about any valuable contribution being made by psycho-analysis to normal psychology. He makes one grudging concession in favour of psycho-analysis to the effect that some older ideas of traditional psychologists, e.g. conative tendencies, voluntary actions, inhibition and self-control, which were fast getting sterile and lifeless, have been much widened, enriched and improved by psycho-analysis. He scornfully rejects the ideas of infantile sexuality and quotes in his favour, Stern, a recognized authority on Child Psychology. He easily disposes of Freud's theory of the origin of civilization and of totem and taboo by stating that these explanations are only 'master-pieces in the art of systematizing phantasies'. As there are no arguments to support these general statements I can only answer that I do not accept Prof. J. Prosad's characterization of these theories as master-pieces in the art of systematizing phantasies. He gives credit to Freud for recognizing recently that the 'Oedipus Complex' has passed away and the universality of the dictum 'the Oedipus Complex is the nucleus of neurosis' has been abandoned. He quotes Freud's statement regarding anxiety 'that everything here is in a state of flux'. If these statements are meant by Prof. J. Prosad to imply that the concepts of the 'Oedipus Complex' and the influence of anxiety on neurosis have been abandoned, I cannot accept his interpretations at all. Oedipus Complex may pass away in normal adults but Freud does not mean that the concept has ceased to be applicable to children. When he said that everything regarding anxiety was 'in a state of flux or change', he never intended to convey the impression that all that had been said before regarding anxiety should be absolutely given up. What he implied, as is evident from his lectures from which the above passage has been quoted and from his later book *Inhibitions, Symptoms and Anxiety*, was that the problem of anxiety needed further analysis. Prof. J. Prosad's charge against psycho-analysis that it has introduced 'mechanistic conception of mind' has been ably met by Dr. Purushottam. The latter has rightly asserted that before Freud there has been no psychological objectivity worth mentioning. I would have very much welcomed a detailed analysis of the developmental impulse to which Prof. J. Prosad refers.

I find myself in complete agreement with one of the main points of Dr. T. Purushottam's article, viz., that the hypotheses regarding the working of the mind which Freud has developed from his study of *Dreams* are applicable to the processes of normal mind. The scope of Freud's discovery remains general. He believes that the energy of the living mind is libidinal. His view that the new concepts of psychology will be more and more applied to Biology, Organic Medicine and other sciences, is one which I wholly subscribe to. His other point about objectivity has already been mentioned.

Prof. J. K. Sarkar thinks that all-prevailing schools of psychology have contributed something towards the progress of psychology. I do not differ from him and I fully agree also with his statement that all complex mental processes like memory, imagination, etc., that are developments of original sense-perception have their root in the Unconscious.

Mr. H. P. Maiti refers to the total impression conveyed by my paper about the worthlessness of non-analytical psychology. I certainly do not hold the opinion that other schools of normal or abnormal psychology have not contributed anything towards the understanding of the mental processes. What I contend is that psycho-analysis supplies the essential element that was missed by them. The discovery of the Unconscious has given an entirely new interpretation to the findings of other schools. I fully agree with Mr. Maiti that the difference between him and myself

is mainly a matter of emphasis. While he believes that psycho-analysis is only a 'school' among many others, I am inclined to consider it as the foundation of the Science of Psychology and the fundamental basis of all psychological thinking. I fully subscribe to the view that the discovery made by psycho-analysis of the social implications of our behaviour--overt or implicit—is very significant for the future reconstruction of social relations. By adding a very valuable appendix to his paper containing an analysis of the attitudes of the authors of the modern text-books of General Psychology and History of Psychology, he has shown how the principles of psycho-analysis are gradually being appreciated by them. He refers to some difficulties in the way of incorporation of psycho-analytical findings in general psychology. The chief difficulty is a methodological one. I fully appreciate his remark that one cannot ask a Scientist—in the present case the Psychologist—to accept a fact or theory relating to his science without verification for himself. I am glad to say that he himself has shown how the difficulty can be overcome. By his experiments on memory and reaction time he has demonstrated how the rapprochement between psychology and psycho-analysis can be made possible and how psycho-analytical findings can be put to test under traditional laboratory conditions. Another difficulty lies in the new terms and concepts of psycho-analysis which appear to be too cumbrous to many and to be substantive in their import. Psychology has been trying to get rid of the belief in the mental substantives and it is difficult for them to reconcile themselves easily to the new terms. I do not think that the difficulty is an insurmountable one and as he himself has suggested symposium discussions and conferences may in the near future lead to a simplification of the terms and concepts. It would surely be a calamity if conservatism, pedantry, or professional vanity stand in the way of such simplification.

Mr M. N. Banerji seems to accept the socio-behaviouristic standpoint as the criterion of normality. I agree with him when he says that by the discovery of the language of the Unconscious, Freud explored the biggest realm of the Mind. As regards the points of dissension with me, I do not think that it would be relevant to go into the details of the prevailing schools of psychology in order to evaluate their respective contributions towards explanation of the mental phenomena. It was furthest from my intention to maintain that these schools have contributed nothing towards our understanding of the psychological processes. I refer him to the introductory portion of my article. It would have been better had Mr. Banerji defined what he precisely meant by 'depth psychology'.

Dr. N. N. Sen-Gupta generally agrees with what have been stated by me. He has, however, presented the materials in a very logical way, classifying the contributions of abnormal psychology under six different headings. His own view about the methodology of general psychology has throughout been of the nature suggested by the development of psycho-analysis.

11. Ernest Jones, London.

I must confess, parenthetically, to being one of those who feel a prejudice against the term 'Abnormal Psychology'. Few workers have been willing to reconcile themselves to the admission that their psychology is abnormal, and still less the risk of being themselves designated as abnormal psychologists. I should myself, for reasons that will presently be indicated, have preferred to use the term 'clinical psychology'. In England 'medical psychology' is the term most widely used, but it is possible that professional prejudice may have much to do with this preference. In this connection an interesting suggestion made some years ago by Wilhelm Specht may be recalled. He proposed to restrict the term 'psycho-pathology' to the study of abnormal mental phenomena carried out from a purely medical point of view, i.e., the investigation of

the causes, pathological significance, and modes of treatment of such states; and to use the term 'patho-psychology' for the investigation of the same data purely from the point of view of general psychology. Certainly this distinction is well worth nothing, for most of the interest attaching to the intensive study of pathological mental states that has been carried out in the past quarter of a century is clearly due to the startling extent to which knowledge gleaned in this field has been illuminating for other fields as well.

Now the simplest answer to the question of what the study of the 'abnormal' has contributed to the study of the 'normal' might well be given in one word: *the Unconscious Mind.* For this includes all else. It is a much greater gift than bacteriological knowledge was to the study of infectious disease or the circulation of the blood was to physiology. After all, important as the new knowledge was in these two cases, it concerned only one of many elements of the situation. Knowledge of the unconscious mind, however, is not merely an addition to our knowledge of the mind—the study of one more element; it represents the discovery of what the mind as a whole really is, an organ of which the conscious mind is only an external expression. Investigation of the unconscious has made it for the first time possible to begin to elucidate the significance of that external expression, to which 'normal psychology' has hitherto been confined—and on a purely observational level.

Instead of giving this short answer, however, I would expound the matter in the following way. The outstanding feature that most sharply distinguishes the clinical method, in either medicine or psychology, is that in it attention is concentrated not so much on the investigation of any particular system considered in isolation, or the elucidation of any particular disorder as such, as on the scrutiny of an individual *human being* considered *as a whole.* In this statement there are two important constituents, the stress laid on the words 'human being' and on the words 'as a whole'. The decision to make an intensive investigation of a number of individuals proved to be a much more fateful one than it must have appeared at first. The motive impelling the pioneers to make this decision was the necessity of doing something when confronted by the terribly urgent problem of suffering, and this motive enabled them to overcome just the obstacles that had hitherto been imposed in the way of any penetrating investigation of the mind. The history of the investigation of the body was repeated in the sphere of the mind. To examine the inside of the body had, for centuries, been forbidden as something taboo, not nice, not proper and not right. But the extreme desirability of learning something about what, why or when men suffered from disease at last broke down this prohibition. Examination of the inside of the mind was still longer held up, and mainly by similar obstacles. With this tradition most clinical psychologists have definitely broken. Faced with the grim tragedies of neurosis, they have had perforce to come to close quarters with the intimacies of emotional life, and, much to the horror of their contemporaries, they have proceeded to examine dispassionately the facts in this way brought under their notice.

A clinical attitude, studying the personality as a whole, is more concerned with the scientific problem of the relationship between mental processes than with the more philosophical problem of the ultimate nature of them. One of the outstanding conclusions to which this methodological mode of approach has compelled assent is that the various forms of mental functioning are extraordinarily interrelated and mutually dependent, so that justifiable scepticism arises in regard to such experimental work which professes to isolate such processes as intellectual or memory ones from the rest. This is only one of the many respects in which the clinical method has come into some degree of conflict with the older methods, though the history of science gives every reason to believe that such conflicts can only represent a transitional stage in the development of psychology as a whole.

But clinical psychology has far more to offer normal psychology than scepticism. It has also made positive contributions to our knowledge of a fundamental character. When the study of the mind is approached in this way, with a propensity to consider every problem in reference to the whole personality and with the resolve not to shrink from exploration or the inner mental life, however intimate, wherever necessary, experience shows that it will result in certain characteristic views being taken of mental functioning. These, then, come to be rather distinctive attributes of the clinical method. Four of them may be selected for special emphasis: they may each be memorized by a single word: genetic, dynamic, instinctual, and unconscious, respectively. A few words will be said about them in this order. It will be noticed that academic psychology gives its assent in general terms to three of them, to all except the idea of the unconscious, but they are all taken much more seriously and applied much more rigorously in clinical psychology.

Everyone would, of course, agree with the statement that the mind develops, but a great deal more than this is meant when it is said that clinical psychology views the mind *genetically*. Here the continuity of the mind at different ages is regarded quite literally. It is held that the significance of any given current mental process is not completely known unless the full genesis of it is also known, unless its predecessors can be traced back in an unbroken chain to the beginnings of mental life in the infant. It has been found that many of the older elements of the genesis, and often the most important of these, are not completely transformed into or replaced by their successors, so that a certain amount of their original significance is still retained. The practical effect of this is that many of our impulses, interests, and ideas carry with them an extrinsic significance based on their genetic history, that they represent more than what they purport to. In extreme cases, of which unconscious symbolism is the most striking example, the subject is totally unaware of this surplus significance. The most advanced school of clinical psychology, following Freud, carries this genetic principle to its logical conclusion and maintains that all our later reactions in life are really elaborations of simpler ones acquired in the nursery. The power to modify the more fundamental types of reaction becomes rapidly less as the child grows, and some of us even think that no fundamental change in character can take place after the fourth year of life.

In its *dynamic* view of the mind, clinical psychology comes into decided opposition with the old associationist psychology. When one mental element occurs after another it is no longer possible to think we have explained this by saying that the second element, having been attached to the first through temporal contiguity, or inherent similarity, was aroused by the presence of the first. Dynamic factors such as those designated by the words motive, tendency, purpose, impulse, are sought for in every single instance, however minute, and no explanation is regarded as adequate unless a factor of this kind is demonstrated. This holds even with mental events, such as slips of the tongue and the like, that previously were supposed to 'happen', without any ascertainable reason, and certainly without any motivation. Yet the older views die hard in some fields of work—for instance, in regard to dreams.

A through-going dynamic conception of mental events as essentially the expressions of the interplay of various 'forces' leads to many important consequences. One comes, in this way, to realize that a great number of mental processes come about as compromise-formations, various conflicting forces having contributed to the end result. From the work of clinical psychologists the extent to which conflict between opposing tendencies takes place in the mind, and the importance of such conflicts, is gradually becoming recognized. It is not simply a question of their frequency. Far more important is the matter of their invisibility. There are in fact extremely few expressions of the mind that are pure manifestations of a single impulse or trend. What appear to be so mostly turn

out on investigation to be either a compromise between two or more opposing ones in the unconscious or else a defensive reaction on the part of one trend against another, repressed one. In other words, man is far less of a free agent than he thinks. Most of his activities, interests and opinions proceed from unconscious sources, without his having any inkling of the fact, and are—so to speak—forced on him. This applies even to the more permanent attitudes of mind and character traits, which are usually defences necessary to him as safeguards against repressed and feared impulses. An interesting and important aspect of this knowledge is that there is far less true thinking done than is generally imagined. Most of what passes for thought is rather the fortifying of some prejudice or opinion that is necessary to peace of mind or mental balance.

As befits a discipline of medical origin, the clinical attitude is close to the biological one, and most clinical psychologists feel that one of the chief goals of their work is to be able to state their mental data in biological terms, i.e., in terms of the *instincts*. It has cleared the ground by showing that a number of supposedly inborn instincts with which other psychologists had operated are complex products, and so are capable of resolution into more primary elements. In the second place, the analyses effected by clinical psychologists, particularly by Freud, of the conative aspects of the mind have revealed much of importance concerning the development, manifold fate, and products of the instinctual side of mental life, and it is reasonable to expect that further research along these lines will bring us nearer to the ultimate sources of mental impulse.

This attitude of clinical psychology to the instinctual basis of mind is in harmony with the changed attitude concerning man's place in nature that was brought about by the biologists of the last century. It is in short an extension of the evolutionary view of man into the sphere of the mind, the sphere where, in spite of some tentative efforts of Darwin, those biologists were not yet able to apply the doctrine of evolution. The clinical attitude thus represents a developmental view, not only ontogenetically but also phylogenetically. The psychology of the 'normal', on the other hand retains much of the philosophic basis given it when it was regarded as being entirely distinct from the animals, and has never been truly permeated by the biological view.

Of the *unconscious* I have already spoken. The discovery of its contents and characteristic mechanisms constitute, not a more contribution to psychology, but a revolutionary change in psychology. One now sees the mind afresh, not as a relatively smooth-working machine, but as a complex of subtle defences against the anxiety aroused by the impinging of primitive impulses on external reality, i.e., human relationships.

One of the disconcerting conclusions to which one is compelled by the study of clinical psychology is that, strictly speaking, there is no such thing as a mentally normal human being, i.e., one whose mind has followed a direct path of development. The so-called normal and abnormal mainly represent different modes of reaction to fundamental difficulties in development and adaptation. The fallacy of thinking that the 'abnormal', by which I mean essentially the neurotic, not of course mental defects from organic origin—have anything to do with disease in the ordinary sense has long been exposed. There are moreover good reasons for thinking that the path of development in the 'normal' is much more tortuous and circuitous than in the 'abnormal'. It may sound paradoxical, but I venture to predict that in a not far distant future psycho-pathology will constitute a standard study of psychology, the basis from which the student will proceed later to the more obscure and difficult study of the so-called normal.

There are two objective grounds why this prediction is a very safe one to make. Investigations of the deeper layers of the mind has shown that the basic elements out of which our minds are developed persist with the psycho-neurotic—in the unconscious, it is true—in their original form to a much greater extent than they do with the normal, and further that they present themselves in a magnified and perspicuous aspect as if under a

clear lens, so that from every point of view they are far more accessible to examination there than with the normal. Fundamental complexes, drives and mechanisms, the effects of which radiate throughout the whole mind, can be very plainly demonstrated in the psycho-neurotic when the same processes can often be only dimly inferred in the 'normal'.

The second ground on which the prediction can be based is even more interesting. We know now-a-days that the reason why psychology has lagged so extraordinarily behind all other branches of science is because there exist in the mind—both, be it noted, of the subject and of the object—the most formidable obstacles which interpose themselves in the path of any exploration designed to penetrate below the surface. Unlike any other man of science, therefore, the psychologist is from the beginning to a large extent cut off from the object of his study—the human mind. So far as our present experience goes, there is only one motive strong enough to overcome these obstacles—that of wishing to be delivered of suffering; even the keenest scientific curiosity offers only a very partial substitute for this motive. Now in the history of the world the theme of suffering has been the special concern of three classes of men: of poets, of priests, and of physicians. Until recently it has been the first of these three, the poet, who has contributed most to our understanding of mental suffering, and we owe some of our most precious insight to his flashes of genius. But he is, after all, primarily concerned, not with the understanding of suffering, but with the transmuting of it into beauty or whatever else would raise it to another plane.

The priest's interest, too, has been mainly therapeutic. Starting with a vested interest in a particular cure, he has been chiefly engaged in transmitting his cure to those in need. Nevertheless, the more profound theologians have also furnished us with much knowledge concerning the nature and sources of suffering. They have rightly led especial stress in this connection on the importance of moral problems, notably on the problem of sin—now-a-days called the problem of the sense of guilt. The physician likewise did not proceed very far so long as his attitude was a purely therapeutic one, showing once more how the passion for therapeutics—laudable as it is on humanitarian grounds—has often proved the bane of medicine and has blocked progress in real prevention and cure based on knowledge. Those over-anxious to heal cannot pause to find out how to do so. It was only when the desire to relieve suffering was infused by the scientific thirst for knowledge that we began to have serious insight, not only into the meaning of all this suffering, but—what is still more important—into the dynamic factors that move both the depths and the surface of our minds. In this achievement there is, in my opinion, one man's name that will for ever be pre-eminent, and that is the name of Freud, now so condemned, but in the future to be honoured above all his contemporaries.

### 12. S. C. Mitra's Further Remarks.

I have already communicated my views to the individual participants of the symposium regarding the points raised by them in their respective papers. I think it would be better for all, particularly those who have not as yet taken part in the symposium and who would like to join in the discussion that will presently follow, if the various issues raised be presented in a summarized form. This is what I propose to do now. I shall also add some general remarks to the answers that I have already given.

1. The first point that I would like to refer to concerns normality and abnormality. With regard to this, two questions have been raised: (*a*) whether any distinction should at all be made between normal psychology and (*b*) if so, what should be the criterion for determining normality and abnormality. (*a*) As to the first question, my view is that in the present state of our knowledge the distinction between normal and abnormal psychology must be maintained. I am quite prepared to

admit that by dint of *sadhana* (yogic practices) a stage of *purnajnana* (perfect knowledge) may be attained in which differences disappear altogether and contradictions cease to exist. It will readily be granted, however, that such a stage of knowledge is not going to be within an easy reach of average mortals like the majority of us in the immediate future. It is not therefore unreasonable to assume that differences and distinctions will continue to exist in this imperfect world of ours and consequently normal psychology will continue to be differentiated from abnormal psychology for a long time to come. How then should normality be distinguished from abnormality? This brings us to the second question, viz., the question of the criterion. (*b*) In a paper read before the Indian Psycho-analytical Society, Maiti gave us an admirable resume of all the prevailing views about normality. He pointed out also that up till now psycho-analysis has not attempted to set up any standard of its own for determining the characteristics of normality. It seems, however, that psycho-analysts as well as others have generally employed the social criterion first explicitly formulated in language by Bose. In deciding about the normality or otherwise of human conduct and behaviour, I do not think any other standard but harmony with the prevailing social ideals of the time and place will lead us anywhere. Taken in a broad sense maladjustment beyond certain more or less arbitrarily specified limits may be put down as the only useful criterion of abnormality. Even bodily diseases can then be shown to be but cases of maladjustment between organs and functions.

2. Another point which has been emphasized by many participants is that all schools of normal and abnormal psychology have contributed towards our understanding of mental phenomena. Some have gone into details of different schools of psychology and psychiatry in order to point out the contributions that have been made by them towards understanding human nature.

I am sorry that my article has created an impression that I consider all schools of psychology besides psycho-analysis as worthless. It has never been my intention to deny that other schools of psychology and psychiatry have made valuable contributions towards the solution of psychological problems. In fact, I myself have published papers expressing my views and appreciation of some of the schools of psychology. I fully believe that all the schools help us to understand many of the conditions of mental events and the construction of the mental structure, but what I am inclined to think is that the essential elements is missed by them all. I cannot do better than quote in this connection the beautiful illustration given by Freud himself. 'Just suppose that on some dark night I am walking in a lonely neighbourhood and am assaulted by a rogue who seizes my watch and money, whereupon, since I could not see the robber's face clearly, I make up complaint at the police-station in these words, "Loneliness and darkness have just robbed me of my valuables".'[1] The essential thing to be done is of course to look about for the thief. That is, if I may say so, what psycho-analysis does while other schools of psychology concern themselves mainly with the loneliness or the darkness or with the gestalt loneliness-darkness. I purposely refrain from discussing the merits and demerits of the various schools of normal psychology since as is pointed out by Jamuna Prosad 'the subject-matter of our discussion is not the contributions of normal psychology to abnormal psychology but the reverse'. As regards the schools of psychiatry I don't think that I shall be wrong if I say that the improvement in the outlook and methods that is now noticeable in them, is mainly due to the influence of psycho-analysis. I repeat that I have not separately mentioned Jung, Adler and others' contributions as I believe that valuable factual meterials of these researches as distinguished from the philosophy underlying them, have been incorporated in the psycho-analytical system.

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[1] Freud—*Introductory Lectures on Psycho-analysis*, p. 35.

3. Now I come to the third point, viz., the so-called pan-sexualism of Freud which, I notice, has been raised by only one of the participants. I must admit that I was rather surprised to find this old objection brought out anew. The point has been discussed threadbare in psycho-analytical literature and the erroneous conception about the term sexuality which lies at the root of this objection has been fully exposed. To be shocked at the term 'polymorphous perverse' is perhaps an indication of intellectual and cultural aristocracy and I cannot of course ask anyone to lose his sense of respectability even if that means merely giving up untenable theories and accepting what the logic of facts inevitably leads to. The present objector belongs to the state described as the buffer-state between analysts and their opponents and I follow the advice given by Freud by not entering into polemics with him. Authority is certainly a valid method of proof in many cases but in the face of the outstanding factual evidences collected in a thoroughly scientific manner by distinguished and patient workers, I shall be pardoned I hope, if I do not find my way to accept the opinion of Stern quoted by him, and to reject unceremoniously like him the concept of infantile sexuality.

4. The next point raised concerns Freud's interpretation of art, religion and other cultural products. It is only to draw attention to the fact that in circles which are expected to be well informed, gross misconception about psycho-analysis still prevails that I have referred to this point. I am glad to say that the majority of the participants who have referred to this topic, realize the importance of the contributions made by psycho-analysis towards understanding these cultural products. One gentleman however the critic just referred to has characterized Freud's theory regarding these as 'masterpieces in the art of systematizing phantasies'. In the first place I contend that phantasies have an importance of their own and have a legitimate place in the intellectual and practical lives of men. Before the Taj had materialized in marble on the bank of the Jamuna it had its ideal existence in the phantasies of the Great Emperor. In the second place, I maintain that they have a due part to play in the hypotheses of every science, even of such objective sciences as physics and chemistry. The progress of science is but the gradual concrete realization of phantasies. Lastly, I would point out that the objector has thoroughly failed to appreciate and has therefore completely ignored the patient and painstaking investigations that lay at the root of these theories. In one of his lectures Freud said, 'I have often had the impression that our opponents were unwilling to consider this source (viz., particularly difficult, intense and all-absorbing works) of our statements, as if they looked upon them as ideas derived subjectively which anyone could dispute at his own sweet will'.[1] The lecture was delivered in 1917. It is to be regretted that I have still to refer to this statement of Freud in 1938. As the heart of a frog that is decapitated, still continues its throbbings; old objections, it seems, though robbed of their essential elements, still continue their periodic walking in and walking out of the stage. The audience is amused at their persistent entrances and exits but is not inclined to take them seriously.

It is not Freud and his followers alone who have detected the sex-element in art. 'During the ascent through the animal kingdom an important displacement in the fundamentals of the procreative instinct has taken place. The mass of the reproductive products with the uncertainty of fertilization has more and more been replaced by a controlled impregnation and an effective protection of the offspring. In this way part of the energy required in the production of eggs and sperma has been transposed into the creation of mechanism for allurement and for protection of the young. Thus we discover the first instincts of art in animals used in the service of the impulse of creation and limited to the breeding season . .

[1] Freud—*Introductory Lectures on Psycho-analysis*, p. 208.

It can be a surprise only to those to whom the history of evolution is unknown to find how few things there are really in human life which cannot be reduced in the last analysis to the instinct of procreation.' The above is a quotation not from any of Freud's books but from the *Psychology of the Unconscious* (p. 80) written by Jung whose theories because of their freedom from the so-called sex bias seem to hold a greater sway over the objector's mind.

I do not understand why any botanist who has learned about the process of fertilization, etc. of plants, should lose his power of appreciating the beauties of flowers. Had there been any necessary connection between scientific knowledge about the origin of things and power of appreciating them, the physicians, I think who are intimately acquainted with the anatomy and physiology of the human body, would have been the least susceptible to the charms of the feminine beauty. Experience, however, does not confirm such an ungallant view about physicians. An ounce of research work in the field of arts and æsthetics of the type undertaken by Freud,[1] Jones,[2] Sachs,[3] Warburton Brown,[4] Haldar[5] and others is certainly worth more than a ton of moral denunciation by ameteur critics.

In his book *The Origin of the Sense of Beauty* (published in 1908), Felix Clay says, 'The emotion of sex is one of the emotions that plays a highly important part in art feeling . . . Those who have renounced love, and devoted their lives to religion or art, have still this powerful instinct (sex instinct) acting as an impelling force, though it may take forms in which the direct connection is difficult to trace . . There is an exhilarating fascination in talking to or even seeing, a beautiful woman, that is in a way not unlike the effect of a work of art'.[6] Herbert Spencer who cannot certainly be assumed to have been spoiled by the Freudian system of thought, pointed out 'that the greater part of what we call beauty in the organic world is in some way dependent upon the sexual relation . . . It is interesting, too, to observe how the conception of human beauty is in a considerable degree thus originated. And the trite observation that the element of beauty which grows out of the sexual relation is so predominant in æsthetic product . . . in music, in the drama, in fiction, in poetry . . . gains a new meaning when we see how deep down in organic nature this connection extends'.[7] I may also mention here that in an experiment conducted by me the surprising fact revealed itself that even such simple experience as æsthetic preference for lines, curves and other forms was determined to a large extent by reference to the human body.

The bringing into relation by Freud of such an ennobling cultural product as religion with such a gross physical matter as sex has given offence to the same participant. Besides referring to the observations that I have made just now with regard to the criticisms of the psychoanalytic theory of art. I may add that psycho-analysts are not the only guilty and gullible persons who have been struck by the sexual significance of many of the forms of religious practices. In an excellent treatise, Simpson Marr, a graduate in Divinity, has considered in details the relation

[1] Freud—'The Relation of the Poet to Day-dreaming,' *Collected Papers*, Vol. IV, pp. 173–83.

[2] Jones—'A Psycho-analytic Study of Hamlet,' *Essays in Applied Psycho-analysis*, pp. 1–98.

[3] Hans Sachs—'Aesthetics and Psychology of the Artist,' *Int. J. P.*, Vol. II, pp. 94–100.

[4] J. Warburton Brown—'Psycho-analysis and Design in the Plastic Arts,' *Int. J. F.*, Vol. X, pp. 5-28.

[5] R. Haldar—'The Working of an Unconscious Wish in the Creation of Poetry and Drama,' *Int. J. P.*, Vol. XII, pp. 188–205.

[6] *Op. cit.*, p. 101.

[7] H. Spencer—*Principles of Biology*, Vol. II, p. 253.

between sex and religion from various standpoints. He mentions that William Blake considered religion to be merely the corruption of sex. D. L. Lawrence 'bitterly attacked the Church and the clergy for the attitude they adopted towards sex ',[1] and perhaps driven to extreme 'by the narrowness and futility of the Church with regard to this great theme he sought to make of sex a new religion and he went so far as to say that the way to find God was to find Him through woman'.[2] One of the noted writers and critics of the modern times C. E. M. Joad who is perhaps further away from psycho-analysis than our present objector, has in one of his books, discussed at some length Freud's theory of the origin of religion. After pointing out where he differs from Freud he concludes 'with most of what they assert I am largely, if not entirely, in agreement. I think that the interpretations they give of the origin of religion in terms of the needs which it fulfils, and grounds of its appeals in terms of the wishes that it rationalizes, are in the main true '.[3]

I refrain from quoting passages from other eminent thinkers of the age, like Bernard Shaw, Bertrand Russell, etc., who have appreciated the fact what the codes of religion are somehow intimately connected with the ways of sex. What the psycho-analysts have attempted to do is merely to make a scientific study of this intimate connection and to elucidate the points of contract. In this attempt they have created a host of antagonists. The opponents have taken every possible opportunity attacking the analysts from their vantage ground of aristocracy and respectability. Unfortunately their objections and rejections are not always based on an examination of the materials and so even when they are convinced against their will about the truth of the psycho-analytical findings they still prefer to cherish their old previous opinions. Even if the studies by eminent anthropologists and antiquarians of the various forms, rites and customs of religion of the primitive people be left out of account, an unbiassed critical and historical study of the rise and development of any religion will, I am sure, sufficiently make out a case for the fact that sex is one of the most important basis of religion and will thus corroborate the psycho-analytical interpretation.

It has been pointed out by Freud himself and many other writers on several occasions before, that the objections of the type cited above to infantile sexuality and to the connection of sex with art, religion and other products of culture generally arise from a misconception of what is meant by sexuality in psycho-analytical literature. It is, of course, difficult to give a precise meaning of the term 'sexual'. In psycho-analysis, the term has got a wider connotation than the popular meaning of it. In popular view sexuality means something improper and something connected with reproductive function. A little logical consideration together with psychological examination of collected facts will clearly convince anyone that this view is an unnecessarily narrow conception. It is a credit to psycho-analysis that it has restored to the word sexuality its true breadth of meaning.

5. I shall now touch upon the question of anxiety and Oedipus complex which have been raised. Says one of the participants 'credit must be given to Freud for recognizing recently, this much at least, that Oedipus complex has passed away and does not exist in the normals and greater credit still for his more recent assertion even in regard to the neurotics, that "we shall have to abandon the universality of the dictum that the Oedipus complex is the nucleus of the neurosis".' He regrets that the followers of Freud 'still stick first to the old and abandoned ideas of their leader and are too slow to follow his pace of progress '. In reply, I think, I must first of all congratulate Freud for the felicitation that he has received

[1] Marr—*Sex in Religion*, p. 15.
[2] *Ibid.*, p. 15.
[3] Joad—*The Present and Future of Religion*, p. 124.

from the participant. In the next place, I must admit, that I have not been able to follow precisely what exactly is the point that has been stressed so much and for which credit has been given to Freud. Bose's recent studies seem to show that even in normal persons Oedipus complex does not really pass away. Even accepting the ordinary meaning of Freud's statement 'Oedipus complex has passed', I do not think that Freud thereby advises his followers to give up the conception of the Oedipus complex altogether. When I say that the childhood of my friend has passed, I certainly do not mean that his childhood never existed and that like Sukdev of the Puranas he was born a full grown adult with mature wisdom. Probably, like the world famous critic referred to by Freud in his *New Introductory Lectures on Psycho-analysis*, my friend here is labouring under some misconception. The critic said to Freud, 'I am only a literary man, and you are a man of science and discoverer. But there is one thing I should like to say to you: I have never had any sexual feeling for my mother'. Freud replied, 'But there is no need at all for you to have been conscious of it, such processes are unconscious in grown-up people'. 'Oh so, that's your idea,' said the critic greatly relieved and pressed Freud's hand. It is my hope that one day our present objector as also many others like him, provided they patiently pursue their study of psycho-analysis in the proper scientific way will similarly feel greatly relieved and say, 'Oh so, that's their idea'. It must be admitted also that changes have been recently introduced and modifications made in the system of ideas that were so long current regarding the origin and states of anxiety. Here too we should not fall into the error of supposing that all that have been said heretofore regarding anxiety should be scrapped altogether and that we should have to start again with a clean slate. In one of his latest books *Inhibitions, Symptoms and Anxiety* (published 1936) says Freud, 'there is no need to be discouraged by these emendations in our theory. They are to be welcomed if they do something towards furthering our knowledge, and they are no disgrace to us so long as they enrich rather than invalidate our earlier views . . . by limiting some statement, perhaps that was too general or by enlarging some idea that was too narrowly formulated'.[1] It will thus be seen that neither the concept of the Oedipus complex nor the concept of anxiety has been given up, rather both have received deeper significance.

6. I next come to the doubt that seems to be entertained by some about the scientific nature of psycho-analysis. The theories of psycho-analysis, they maintain, are not capable of being verified by laboratory experiments and hence they hesitate to accept psycho-analysis as a scientific discipline. I readily agree that experimentation in the above sense is difficult to perform in the field of psycho-analysis. Maiti has shown that though difficult it is not impossible to devise suitable laboratory experiments in order to test the validity or otherwise of psycho-analytical findings. I think, however, that laboratory test should not be considered the only criterion of deciding about the scientific nature of a discipline. Experiments are not possible in many of the recognized sciences, but nobody denies their scientific character. Close systematic study of facts patiently collected and minutely observed and logical treatment of the data, these are the essential characteristics of a science. I am yet to find a person who has gone through the writings of Freud and has not been struck by his patience in the collection of facts, his unprejudiced scrutiny of the materials and the solid foundations of his theories. To depend on experiments alone in estimating the scientific character of a branch of study is to betray a form of intellectual weakness which has been very aptly described by Franz Alexander. Referring to the modes and virtues of modern research he notes the danger that confronts the scientific workers of the present day. Says he, 'This danger is not restricted to scientific

[1] *Op. cit.*, p. 148.

laboratories, it is a general problem of the present age. Man, the inventor of the machine, has become the slave of the machine: and the scientist in developing highly refined methods of investigation has become not the master but the slave of his laboratory equipm . . . . A naive belief in the magic omnipotence of the technical procedure leads to a routine, often sterile submersion in details without interest in or understanding of larger connections '.[1] It is this attitude that leads many to regard 'suspiciously everything that entails reason and not merely observation' and to be, he continues, 'comtemptuous about theories, not to say hypotheses, that are yet not proven. There is a naive adoration of "pure facts" which are collected without any leading ideas '.[2] So even though psycho-analytical theories may not be subjected to the control of the laboratory technique I do not consider that the scientific character of psycho-analytic procedure is thereby prejudiced in any way.

7. A difficulty in the way of rapproachment between psycho-analysis and psychology has been pointed out specially by Maiti. Psychology cannot easily give up the terms and concepts that it has arrived at by the fruits of its labour for centuries and cannot readily assimilate the new technical terms of psycho-analysis. I feel the difficulty to be a real one. A way should be found to get over this difficulty. Perhaps conferences and symposium discussions will be able to render help in this respect, provided there be no mutual suspicion between academic psychologists on the one hand and the professed psycho-analysts on the other. I am doubtful, however, as to whether symposium discussions, as has been suggested by another, will be able to decide about the truth or otherwise of a particular psycho-analytical theory, because I feel that in such discussions moral and other extra-psychological considerations are likely to create unnecessary obstructions.

8. I am surprised that psycho-analysis has been accused of doing a positive disservice to psychology by introducing mechanistic conception. One of the fundamental conceptions of psycho-analysis is dynamism and if psycho-analysis has rendered any service to psychology it is its emphasis on the dynamic aspect of mind that should be given a pre-eminent place. The nature of this dynamism has been very well expressed by another participant who has said that before Freud there was no psychological objectivity worth mentioning and that 'objectivity in psychology is achieved only when the object of psychological study is grasped as the living Mind what lives on more than food, what shapes and uses the instrument of its action and grasps all things of the world for the sweetness thereof'. If it be deterministic view of mind that is sought to be assailed by the statement I have only to point out that determinism lies at the root of all sciences and psycho-analysis cannot claim any conception.

9. Seeing that psycho-analysts explain the custom of burial as a return to the mother's womb, they have been challenged by one of the participants to give a psycho-analytical explanation of the custom of cremation. I frankly admit that I have no ready-made explanation to satisfy him, neither do I know of any explanation of this custom in current psycho-analytical literature. There is no death of men of poetical and fanciful imagination among psycho-analysts and if psycho-analytical theories are nothing but systematization of phantasies it is rather curious that no one has yet waved into a theory of cremation.

10. These are the main points that have been stressed in the symposium articles. Before concluding I would like to mention one other point which concerns me personally. When the President of the Psychology Section requested me to open the symposium, I confess that I felt nervous because of the vastness of the task that was entrusted to me. To en-

[1] Alexander—Introduction to Mortimer Adler's work, *What Man has made of Man*, p. ix.

[2] *Ibid.*, p. x.

compass within a space of ten type-written pages all that can be said about contribution of Abnormal Psychology to Normal Psychology is certainly a difficult problem. After due consideration I thought that it would be best under the circumstances to confine myself only to broad general problems and to begin with a short introduction, briefly touching upon the other prevailing schools of psychology. That is the reason why I have not gone into details either of any school of psychology or of any particular problem. My thesis was and still is that it is psycho-analysis that metamorphosed academic psychology and has made the latter a living science. I have tried to the best of my ability in the original paper as also in my subsequent statements to present evidences for my thesis. I may mention that in this effort of mine I have only attempted to supplement what has already been given expression to by Bose in his article on *Psychology and Psychiatry* (I. J P., Oct., 1931) and Maiti in his *Concept of the Unconscious in the Mental Processes* (Pro. 4th Phil. Cong., 1930, p. 341).

### Observations by other Psychologists.

Lt.-Col. J. E. Dhunjibhoy's reference to concrete cases proved highly amusing as well as instructive. Dr. N. N. Sengupta and Dr. Indra Sen emphasized the methodological aspect of the problem, while Prof. H. D. Bhattacharyya stressed the social point of view in the determination of normality. Dr. Purusottam referred to the contribution made by Prof. Spearman. Dr. N. S. N. Sastry pointed out that ancient Indian Psychology recognized the importance of 'Kama' in the mental life of man. Dr. S. K. Moitra also drew attention to researches in ancient Indian Psychology, Messrs. U. S. Gheba and S. P. Aranya and others took part in the debate. The new points raised were answered by Dr. S. C. Mitra and the discussion was finally summed up by Dr. G. Bose.

## XIX. THE APPLICATION OF STATISTICS IN AGRICULTURE.

*(Section of Agriculture, in co-operation with the Indian Statistical Conference.)*

[No report of the discussion has been received.]

## XX. RECENT ADVANCES IN MOLECULAR STRUCTURE FROM THE PHYSICO-CHEMICAL STANDPOINT.

*(Sections of Mathematics and Physics and Chemistry, in co-operation with the Indian Physical Society.)*

1. Dr. K. N. Mathur, Lucknow.

   *Magnetism in relation to molecular structure.*

2. Dr. Mata Prasad, Bombay.

   *X-Ray and molecular structure.*

3. DR. R. K. ASUNDI, Aligarh.

4. DR. P. N. SEN-GUPTA, Kohlapur.

5. DR. H. K. TRIVEDI, New Delhi.

6. DR. D. M. BOSE, Calcutta.

7. DR. K. S. KRISHNAN, Calcutta.

8. DR. S. N. BOSE, Dacca.

[No report of the discussions has been received.]

## XXI. THE POSITION OF ENTOMOLOGY IN THE INDIAN UNIVERSITIES.

*(Sections of Zoology and Entomology.)*

A joint discussion on 'The position of Entomology in the Indian Universities' of the sections of Zoology and Entomology was held in the Zoology section (Chemistry Room I, Presidency College, Calcutta) on January 7, 1938, at 11 A.M. under the chairmanship of Prof. G. D. Hale Carpenter, Oxford.

1. MR. M. SHARIF, Aligarh.

The importance of Entomology to Agriculture, Medicine, Veterinary and Forestry, and the rapid advance that has taken place during the past 30 years reveals a changed outlook. It is desirable that the teaching of Entomology should be placed on sound footings. Separate Departments of Entomology independent of Zoology should be started in the Universities. Entomology should be given an equal status with Zoology and Botany. It is, however, essential that an advanced student in Entomology has a good foundation of Zoology but if the Departments of Entomology are not separated from Zoology, then there is danger of Entomology being ignored, as is happening to-day in the Indian Universities.

2. MR. DURGADAS MUKERJI, Calcutta.

Insects play a very important rôle in the life of an agricultural and tropical country: (i) in health, (ii) in agriculture as pests of crops, etc. and in pollination of flowers, (iii) in cottage industries—sericulture, apiculture and lac.

Besides, Entomology presents scope for problems of wide scientific interest—adaptation, colouration, mimicry, genetics, etc. etc.

The vastness of this science necessitates its study as a full subject. India offers problems of applied value which require trained Entomologists to study. Entomology should be included as a special subject at the post-graduate stage of the Zoology course.

At present provision for teaching and research in advanced Entomology in Indian Universities is meagre.

Agricultural Institutions should not be burdened with the teaching of advanced Entomology, which should be the duty of the Universities.

Co-operation between Universities and Agricultural and Medical Institutes is necessary for the teaching of advanced Entomology.

3. DR. D. P. RAICHOUDHURY, Calcutta.

As compared to the Universities in Europe, America and Japan the position of Entomology in the Indian Universities is disappointing. Applied Entomology has an important bearing on improvement of agriculture in India.

Separate Entomological Departments should be established in Universities and senior Zoology students taught advanced Entomology with particular reference to applied Entomology.

Encouragement should be given to teachers and students to take up Entomological investigations.

Special attention should be paid to problems connected with sericulture, apiculture, lac industry and insect pests of fruit, vegetables, stored products, timber and tobacco. Business men connected with these industries should be brought into closer contact with the Universities for mutual help.

4. DR. HEM SINGH PRUTHI, New Delhi.

The present position of Entomology in Indian Universities and courses in Agricultural College. Post-graduate training at the Imperial Agricultural Research Institute and elsewhere. Difficulties in finding students with adequate fundamental knowledge of the science of Entomology. Post-war development of Entomology in European and American Universities. Place of Entomology in a Zoology course for the degree examination and in post-graduate work. Need for trained Entomologists. Scholarship for post-graduate training—Indian Central Cotton Committee, the Imperial Council of Agricultural Research and Universities to provide these.

5. DR. P. SENIOR-WHITE.

I am only intervening in this discussion of teachers of this subject, because I have under me about a dozen posts in what is really no more than applied Entomology. When I started, *ab initio* the Malaria Section of the Medical Department of my Railway, the finding of subordinate staff presented great difficulties. Naturally, I started with the qualified Sanitary Inspector. I found, in this country, that his knowledge of Entomology from his course consisted in telling an Anopheline from a Culicine larva. He could not use a dichotomic key and has no familiarity with a microscope. [All malaria control under me is strictly by species and involves larval and adult identification . . . . ] I then tried the Sub. Asst. Surgeon, and found him equally ignorant in all those aspects. Gradually other types of applicants approached. The B.Sc. (Agric. or Zoology) can use a microscope, and a key, and quickly learn the common forms of culicid systematically on which malaria control is founded. I am now giving preference to applicants so qualified.

But, malaria control is not pure Entomology. It involves some acquaintance with Botany and other Sciences, involved in Ecology, which would not be available if a man has specialized throughout his University career in Entomology only. I therefore suggest that a basic training in general zoology, prior to specialization in Entomology, should not be departed from. But, as training in Malariology at Karnal, Shillong, is confined to those with a medical qualification, I would urge that some Indian University make a similar course to Karnal available to the Zoologist.

6. PROF. B. K. Das, Hyderabad.

Entomology is a growing science and is of utmost importance to the national welfare of India. It should be taught as special subject in the Post-Graduate classes in the Universities. Where there is a department

of Zoology a Reader or a Lecturer in Entomology should be appointed—in a word, it should be a special part Zoology.

7. Dr. S. Pradhan, Lucknow.

The importance of Entomological studies is undoubtable, unquestionable and immensely great and any amount of repeated stress on this point is not out of place.

*Entomology as part of Zoology Course*:—In the study of zoology we have to do equal justice to the whole of the animal kingdom and the animal kingdom consists of so many phyla and each phylum consists of so many classes; thus out of a very large number of classes the class Insecta is only one. The student of Zoology, therefore, can afford to devote a negligibly small portion of his time and energy to the study of Insects, as from the pure knowledge point of view all classes are regarded of equal status and some times a single genus like *Peripatus* constituting a separate class is given more attention than the whole of the insect world. It is therefore absolutely impossible to do full justice to Entomology until and unless it is raised to an equal status to the rest of zoology. As a justification for this suggestion reference may be made to the study of Metcalf and Flint (Destructive and Useful Insects) which graphically shows that the number of the known species of insects is many times larger than the total number of the rest of the species of the animal kingdom. Even from the purely academic point of view, therefore, it should not be regarded as being unjustified to demand an equal status for Entomology.

*The Attitude of the Universities*:—The next question is as to what attitude the Universities should adopt under the present circumstances, i.e. so long as Entomology is not raised to an independent equal status due to financial and other difficulties. In this connection I may refer to the practice followed at Lucknow. In this University, the provision is such that if a student decides in time to specialize in Entomology (also in other groups) he is allowed one full year, after the Honours course to devote exclusively to the study of insects. In this year he is expected to specialize in insects for the M.Sc. degree, i.e. to make a general study of the various aspects of Entomology and thus to prepare himself for a more intensive work in any particular problem. As to how far this practice is beneficial or otherwise this distinguished gathering can best decide, but as a student of the same system I may give my evidence that this is very useful practice. To be allowed to devote one full year to general Entomology before confining to any particular problem is very useful from the student point of view, and if the other Universities encourage this practice they will be doing their duty at least in some measure, to this important science of Entomology.

*Difficulties in Entomological Studies*:—It is an absolutely established fact that due to the absence of reference collections, Taxonomic work is an utter impossibility in most of the Indian Universities. The best way in which the Universities can serve this important science is by contributing morphological and physiological studies on the various groups of insects. Intensive morphological studies can prove of great help in determining the economic value of insects. The importance of the study of mouth parts has long been recognized in Economic Entomology, and the historical and physiological studies of the insect gut promise valuable results for the use of economic entomologist. The gulf, as a matter of fact, between the academic and applied aspects of Entomology is lesser than the gulf between pure and applied aspects of other sciences. It is therefore desirable that the Universities and research institutions should join hands and march to a common end. There should be only a simple division of labour so that pure Entomology may be tackled at the Universities and applied aspects at the research institutions.

8. Prof. G. Matthai, Dr. Ayyar and a number of speakers felt the necessity of strengthening the teaching of Entomology in the Indian

Universities and the desirability of introducing the subject in our Universities.

9. PRINCIPAL AFZAL HUSSAIN, Lyallpore, moved the following resolution in the full session, seconded by Mr. Mukherji, Calcutta.

'That on account of the growing importance of Entomology fuller facilities for the teaching of Entomology should be provided by the Indian Universities.'

The resolution was carried unanimously.

## XXII. BIOLOGICAL CONTROL OF INSECT PESTS.

### (*Sections of Entomology and Agriculture.*)

A joint discussion on 'Biological control of Insect pests' of Sections of Entomology, Zoology and Agriculture was held in the Zoology room (Chemistry Room I, Presidency College, Calcutta) on January 4, 1938, at 1-30 P.M. under the chairmanship of Prof. P. A. Buxton, London.

1. MR. DURGADAS MUKERJI, Calcutta, opened the discussion.

Under Indian conditions only cheap methods of insect control, which do not demand any special skill or knowledge on the part of the farmer, have any such chance of success. Biological control of insect pests satisfies the above conditions. Possibilities of biological control in India: A number of parasites of insect pests occur in this country in different parts, some of these have been profitably employed by American and Australian fruit growers. Before biological control can be attempted a thorough knowledge of parasites is essential.

A Central Biological Control Research Laboratory should be established to collect data, prepare reports and lists of natural enemies of insect pests and to breed such useful insects and distribute them among the cultivators. This organization should also carry out investigations on the principle of biological control, and study the bionomics of parasites and their ecology. Universities specializing in Entomology should institute scholarships for the purpose.

Research work should be conducted to raise disease-resistant varieties and to study the incidence of pests in relation to soil conditions.

2. DR. P. SEN, Calcutta.

The success of biological control of insect pests depends on accurate knowledge of the ecological factors which govern an insect outbreak. Insects may be controlled biologically through their parasites, by some physiological or physico-chemical changes in their environments, or by producing immunity in their hosts. The methods naturally vary in different spheres of applied Entomology. In the domain of medical Entomology biological control of anophelines through fish have given very confusing results. The fish do not appear to be very useful in reducing the anopheline fauna under natural conditions in Bengal. On the other hand by disturbing the nitrogen cycle of the soil and its saline contents a change in the fauna of a breeding place may be brought about and a natural control of a noxious species effected. By controlling the food factors of anophelines through some changes in the flora in their habitat, control of particular species may be effected. Success of control through parasites depends on the determination of the true nature of the parasite to be used. Superficial knowledge is of no use.

For instance *Eurotoma saliciperdæ*, a chalcid long regarded as a parasite of the cecidomyid midge *Rhabdophaga saliciperda* has been found to be nothing more than an inquiline. Several other instances of the same type may be cited.

It is only after careful prolonged researches that biological control can be placed on a sound footing.

3. MR. S. N. GUPTA, Ranchi.

A selective sequence of parasites and predators, which will attack the injurious insect in different stages of its development, so that the component members of this sequence will act in harmony, is essential to effect a successful control. Further the parasite should be capable of outnumbering its host, there should be a higher percentage of females in its progeny, greater number of generations and ability to locate and attack the host. It should be specific where the host has overlapping generations and polyphagus where there are no overlapping of generations or when other factors render the particular stage of the host not easily available.

The importance of predators or parasites as biological control to a certain injurious insect depends on a large number of factors, but where available, predators are more important and effective than parasites.

Artificial (mechanical, physical or chemical) and biological control measures are supplementary to each other rather than incompatible.

4 DR. HEM SINGH PRUTHI, New Delhi.

The employment of parasites as a means of combating pests is undoubtedly the ideal method when successful. A large number of entomological workers in different countries are engaged in studying this method, in some cases success has crowned their efforts. In several cases attempts have been made rather prematurely without proper study. The first and foremost requisite is a critical ecological study of the host and parasite in the laboratory and in the field. The influence of different environmental factors on the fecundity and longevity of the pest and parasite must be ascertained, the vital limits established, the rate of development and mortality of the different pre-imaginal stages under different conditions investigated. It would then be possible to ascertain the comparative or differential effects of environmental factors on the host and its parasite and to take advantage of conditions which are favourable to the parasite but unfavourable to the host.

Successful cases of biological control belong to the category of introduced parasites and when optimum environmental requirements have been obtained in the new country. It will be of little use to attempt the introduction of a parasite into a country with a climate very different from that prevailing in the insects' original home. Moreover, before attempting such introduction the potentialities and possibilities of the insect as a pest of any crop plant and its reactions on other useful parasites must be worked out.

It is a fact that no outstanding successful case of biological control can be cited from continental regions, but this should not deter workers in India from exploring the possibilities. There are important physical and climatic factors and extensive mountain and desert belts which act as fairly effective insect barriers dividing India into zones, each with its typical insect fauna, very much like the islands or insular regions where successes by biological control have been obtained.

With indigenous parasites, in spite of mass-multiplication and liberation, little success has been achieved. It is argued that although the population of an indigenous parasite in nature may be low the total number in a locality is far too high to be appreciably affected even by apparently large subsequent liberations. This is not always true. There

are cases in which an adverse season seriously reduces the parasite population without affecting the host to the same extent. Therefore the parasites come into prominence very late in the seasonal activity of the host in nature. The numbers of a parasite in the beginning of the competition cycle may materially help the parasite to get a good start, and mass collection of the parasite during its abundance and helping it to pass unfavourable season either under artificial optimum conditions or at a temperature low enough to arrest its development without impairing viability, may help.

5. P. N. Krishna Ayyar, Coimbatore.

*Some aspects of Biological Control.*

Possibilities of biological control particularly in respect of an indigenous insect like *Pemphers affinis* Frh, the cotton stem weevil of South India. I have been actually engaged in exploring the possibilities of the biological control of this weevil borer for the last two years and I wish to narrate my experience and methods of tackling the problem so as to prove that this method, though based on sound principles, is not so easy as is often represented. It requires great care and technical skill. There are many factors to be studied which are unknown.—We have to know all about the pest and parasites and their ecological complex of factors. Concerning the pest, it has to be ascertained whether the pest is an introduced one or indigenous for the methods differ in the two cases. As most successful cases of biological control are found in cases of imported pests, there arises the question whether native pests can be successfully tackled by this method. As Thompson says this method is universally applicable under favourable conditions. An instance to prove this may be taken from leap . . . . beetle of coconut in Fiji. In the case of a native insect the same principles as those of an introduced pest hold good. Only instead of finding the original home of the imported pest we have to find out the original habitat of the native pest. From its original habitat the natural enemies may be brought and introduced in cultivated areas. My search has proved that in the case of this weevil its original habitat is not probably cotton but some wild plant. I have also obtained a few parasites which are absent in cultivated areas. It remains to be seen whether these parasites will establish and accommodate themselves in cotton fields.

6. S. Pradhan, Lucknow.

In Biological control effort is generally made to find out some predator or parasite which directly and immediately attacks the insect which it is desired to control. In this effort a lot of energy is spent, and when a suitable predator or parasite is not found locally, effort is made (often with failure) to transport a suitable controlling agent from other parts of the world. May I put forward my belief that much success may be obtained if energy is concentrated on an intensive study of local Biology specially the relation of one living being to another in a certain area. This study is sure to reveal what may be called the Local Balance Cycles in which one living being is dependent on the other. After such balance cycles are ascertained it will be easy to spot out the weakest point in the cycle whence it is easiest to disturb the balance and thus to control a particular insect pest.

7. Dr. T. V. R. Ayyar, Madras.

I referred to my paper on this subject read at the Benares Session of the Congress in 1925. Having no time to speak on all the salient points I referred to the following as the most important points in this matter.

(i) A thorough and systematic and bionomic study and survey of the entomophagous insects of India so as to know what are the forms we have in India at present.

(ii) The importance of various kinds of parasites and complexes connected with insect pests so as to eliminate the injurious from biological forms. This required a good deal of artificial breeding and careful release of the beneficial forms.

A slide of the *Nephantis* caterpillar complex was exhibited to show this difficult aspect of parasitism.

I then referred to same work in India in connection with the cotton boll worm the coccid *Iorgx* recently introduced in S. India and then on the work done in Madras on the coconut caterpillar *Nephantis*. I concluded by saying that, though the method is really very tempting and easy if *succcssful* the method is not so very easy as many of us wish to think it to be. As I said before a good deal of careful work has to be done. I also exhibited a slide of the efficient prickly pear cochineal which was used in S. India extensively with great success. I concluded by warning entomologists and agriculturists that the method though very desirable and efficient is not such an easy method to accomplish.

8. Prof. G. H. Carpentor, Oxford, remarked that how in Africa in case of Tsetse flies by changing the environmental conditions the pests can be brought into a check.

## XXIII. ANIMALS AND THEIR DISEASES IN RELATION TO MAN.

### (*Sections of Medical Research, Veterinary Research, and Physiology.*)

Professor Sir Frederick Hobday, London.

In India as well as in England there are certain diseases of animals and man which are of mutual interest to the medical man and the veterinarian, whether on account of their analogies or their differences, or by reason of the fact that they are contagious from animals to man, or *vice versa*; and it is not wise for either branch of medicine, nor yet for our mutual patients, for us to work in watertight compartments. It is better from every point of view that we work in collaboration. Some diseases, such as cancer, tuberculosis, anthrax, and tetanus we attack respectively in somewhat different ways; whilst others, such as glanders, rabies, foot-and-mouth disease, mange, and ringworm, can only be effectively dealt with by definite collaboration between medical men and veterinarians. There are others in which as yet there has been no effectual attempt at collaboration. Such ailments as common catarrh and the influenzas can be dealt with to mutual advantage from a comparative aspect, as can more complicated ailments such as Hodgkin's disease, and such common ailments as rheumatism and fibrositis. An exchange of ideas as to the symptoms, methods of spread, etc. in our various patients is of undoubted help towards elucidation. In veterinary medicine, equally with the human side, the study of collateral branches of science, such as entomology or parasitology, is of material help, and in teaching colleges, as in hospitals, a knowledge of the life-histories of the various flies and insects which act as carriers or transmitters of parasites is as essential to the veterinary student as to his medical confrère. In the clinical world, too, we have many points in common, for

our animal patients suffer from gastritis, indigestion, colic, internal parasites, colitis, swallowing of foreign bodies, and various forms of pneumonia and heart disease, to the same extent as human patients do, and our veterinary treatments are similar in principle to those in human practice. The veterinarian has, however, a greater variety of internal arrangements to deal with, having to take into account whether his patient is herbivorous or carnivorous; or whether, as is the case in man, it will eat anything and everything which it has an opportunity of eating. Some of our patients have only one stomach, whereas others have four—while the camel stands by itself in having three—so that their respective digestive processes vary very much in detail.

I feel sure that when a number of these diseases, both epidemic and otherwise, are studied from this point of view, we shall be able to advance more quickly and find many new ideas and theories, which up to the present have not been thought of. It is not only in Great Britain that diseases may be studied in this way, for those who live in the tropics have also plenty of opportunity for following up comparative medicine. The different effects which various foods have on man and animals also form a good illustration. For example, the flour of certain forms of Indian pea has a nerve-paralyzing effect not only on the natives continually fed on it but also on horses, producing laryngeal paralysis which causes dyspnœa on the slightest exertion. Again in entomology, in the study of the life-histories of the various flies and insects which act as carriers and transmitters of disease-germs or blood-parasites, the knowledge acquired by collaboration is of mutual benefit in epidemiology, not only in the diseases transmitted from animal to animal but in those transmitted from animal to man. In the short time now at my disposal I shall confine myself to a selection of a few diseases concerned with Public Health, which are communicable from animals to man, in the treatment of which the practitioner of human medicine can obtain material help from collaboration with his veterinary confrère.

*Glanders.*

This is primarily a disease of the hors etribe, and affects horses, asses, and mules. Its cause—the *Bacillus mallei*—is an extremely dangerous organism to work with in the laboratory. The disease is one which is most commonly met with amongst stable-workers and those who come in contact with horses, and a man can be readily infected by the discharge from the nostrils of an infected horse or even by handling the brushes, sponges, or stable-cloths, which have been in contact with a glandered horse. In the South African war it accounted for the deaths of many thousands of our Army horses, and indeed in all wars it has been the bugbear for which the Army veterinary officer must always be on the look-out.

It is so insidious that, until it has been present in the system for a certain length of time, its presence may remain unsuspected. Modern veterinary science has now, however, at its command a method by which the presence of glanders can be ascertained, for by the introduction of a few drops of mallein (a special preparation made from the *Bacillus mallei* itself) the skilled veterinarian can make a diagnosis with certainty within forty-eight hours, even if the animal is infected only in the slightest degree. During the Great War, by means of this test, applied by the officers of the Royal Army Veterinary Corps, glanders was entirely eradicated from the horses and mules of the British Army, and it has been applied so successfully in Great Britain that at the present time the disease has absolutely ceased to exist. This means that not only has it been eliminated from the list of ailments which the veterinary surgeon is called upon to diagnose, but it has also been eliminated from the list of diseases in man; and in an island country like Great Britain so long as the present regulations of the Veterinary Department of the

Ministry of Agriculture and Fisheries are kept in operation the country will be free from this terrible affection. In India I understand that it is still a problem to be dealt with, but of this I hope to hear something in the discussion.

*Rabies.*

This disease has not been met with in man in England for more than thirty years, and it can never appear again as an epidemic in this country, so long as control is kept upon the importation of animals of the dog and cat tribe. The primary cause of rabies in man is the contact of an abraded surface of the body with the saliva of a rabid animal, and whether the infected animal is a horse, a sheep, or any other animal, it has always had its primary origin in a rabid dog and cat. The Muzzling Order succeeded in eradicating the disease from Great Britain, and it then remained for the Veterinary Advisers to the Ministry of Agriculture and Fisheries to take steps to see that it was not reintroduced into the country. This explains the present quarantine regulations imposed on all dogs and cats admitted from countries where rabies exists. The absence of the disease is further proof of the value of the collaboration between the forces of the veterinarian and the medical man in the cause of Public Health. In India you are much more heavily handicapped than we are in England, especially on account of the numbers of pariah dogs, over which, I understand, it is difficult to obtain control.

*Anthrax.*

This condition is, I understand, even more prevalent in India than in England, and is particularly met with in cattle, horses, sheep and pigs; the dog, cat and fowl possess a comparatively high power of resistance to the infection. It is a disease which is always serious and, in animals, invariably results in death. In cattle, especially, death is very sudden, and in Great Britain the Government has imposed laws and regulations which provide that the body must be cremated as near as possible to the place where the animal died. It is forbidden, too, in any way to cut the carcase, for on many occasions those making, or assisting at, the post-mortem have become infected and have died in consequence. In cities and towns in England where wool from foreign countries is handled, disinfection is compulsorily adopted, with satisfactory results. If this practice could also be efficiently adopted in the case of hides, bone manure and other animal products, before they are imported into this country, the number of deaths from anthrax in man and animal would diminish considerably. Cotton, linseed, and other cattle-food cakes come into the same category. Once eradicate anthrax from the animal and animal products and eradication from man would automatically follow. Anthrax is primarily a disease for the Veterinary Surgeon, as it always originates from some product obtained or used by an animal.

*Foot-and-mouth Disease.*

This disease has at times, in the daily Press, provoked a good deal of unwarranted criticism directed against the Veterinary Advisers to the Ministry of Agriculture and Fisheries, yet there is no doubt that, in England, they have adhered to the correct policy (that of 'Stamping out'). We have much upon which to congratulate ourselves when we compare our position with that of other European countries. The cost of Holland, France, Belgium, Denmark, and Germany, amounts to tremendous sums each year, and these countries never get any further forward in the matter, having the disease always endemic. The fact that we are an island is of incalculable value to our Ministry of Agriculture, whose responsibility it is to frame the laws which control the importation of animals from any country from which infection may be brought.

The following statistical table, showing the respective numbers of outbreaks in other European countries during 1934, is convincing evidence :—

| Month | Great Britain | France | Germany | Holland | Belgium |
|---|---|---|---|---|---|
| January .. .. | 1 | 1,074 | 113 | 579 | 329 |
| February .. .. | — | 652 | 80 | 214 | 168 |
| March .. .. | — | 613 | 73 | 105 | 102 |
| April .. .. | — | 287 | 110 | 59 | 81 |
| May .. .. | 1 | 135 | 48 | 51 | 40 |
| June .. .. | — | 146 | 56 | 132 | 36 |
| July .. .. | — | 98 | 27 | 459 | 19 |
| August .. .. | 3 | 92 | 40 | 1,391 | 15 |
| September .. | 4 | 21 | 19 | 3,120 | 20 |
| October .. .. | 24 | 15 | 14 | 2,880 | 9 |
| November .. | 28 | 3 | 16 | 48 | 1,173 |
| December .. | 18 | 28 | 32 | 230 | 20 |

The public should think what a terrible disaster it would mean to a small confined country like England if the disease were allowed to spread, with the fact that milk from cattle affected with foot-and-mouth disease must not on any account be consumed by children or invalids, or be given to goats, pigs, or any other animal.

In India I understand it is always more or less with you but in a much milder form than we get it in Europe and that conditions necessitate curative and prophylactic treatment.

*Tuberculosis.*

This is pre-eminently a disease which illustrates the value of collaboration between the medical man and the veterinarian in the cause of Public Health. No variety of domesticated animal is immune to tuberculosis, although some are more susceptible than others. The goat, the sheep, and the horse are probably the least affected, but even in these it is only a question of degree, and there is no actual immunity when they are placed under conditions favourable for infection. Birds, especially poultry, are frequently affected, and whenever the disease appears amongst them the whole flock may have to be destroyed before it is eradicated.

It is a disease which the practising veterinarian meets with most commonly in cattle, and there are about a million tuberculous cattle in Great Britain at the present time. These are not all dairy cattle, but it is in these that the danger lies for man, as it is well known that at least 40%—and, in some districts, 60%—of them are affected.

At one of the National Milk Conferences Dr. Stanley Griffith, in a paper on 'Bovine tuberculosis and its relation to man', gave some statistics which went to prove more than ever the necessity for medical practitioners and veterinarians to pull together. In an investigation of 1,200 cases of tuberculosis he had found that 87·5% of infections with tuberculosis of the cervical glands, in children up to the age of 5, were bovine; and similarly 61·3% of those between 5 and 10 years; 37·9% of those between 10 and 16 years; and 25% of those of 16 years and over. Of 476 cases of bone-and-joint tuberculosis 28·7% of those under 5 years were of bovine origin; 23·1% of those between 5 and 10 years; 9·5% of those between 10 and 16 years; and 6·4% of those of 16 years and over. Of 126 cases of lupus: 69% of those under 5 years; 42·5% of those between 5 and 10 years; 60% of those between 10 and 16 years; and 17·6% of those of 16 years and over were of bovine origin. The same medical scientist estimates that tuberculosis contracted through the consumption of cow's milk causes approximately 3,000 deaths in young children every year. As all these infections are caused by drinking the milk of cows suffering from tuberculosis of the milk glands, it is hoped

that the new regulations of the Live Stock Industry Bill which came into active operation in January 1937 will, so far as Great Britain is concerned, have the effect of eliminating, in a great measure, the chances of infection from the cow to man.

Although only about 1% of dairy cattle are affected in the udder, and until the infection has reached this organ the milk does not necessarily contain tubercle bacilli, an infected cow is always a possible source of danger, for one can never tell exactly when the udder tissues will become infected and the milk a source of definite and terrible danger to the children to whom it is given.

Pasteurization, undoubtedly, offers some safeguard, but it is generally admitted that some of the valuable properties which raw milk possesses are lost during this process, and there can be no doubt that the best solution of the prevention of infection lies in the endeavour to obtain an absence of the tubercle bacilli at the source of supply –i.e. the dairy herd. That this can be accomplished, if pecuniary and other necessary adjuncts are available, has been proved by actual experiments, and America has been especially go-ahead in her endeavours to form accredited herds. In that country whole districts have been cleared, and the most stringent laws are enforced in order to prevent reinfection by the entrance of tuberculous beasts into these areas.

In Great Britain progress in this direction has been slow, as the British public, although not unmindful of the advantages of tuberculosis-free milk, is not willing, as a body, to pay an extra price for this guarantee. Dairymen who have gone to the expense and trouble of clearing their herds have not received the encouragement they deserve either from the general public or from the hospitals and medical practitioners. These last, in particular, might do a very great deal more than they are doing to assist in educating the housewives and mothers of young children as to the dangers of tuberculous milk, by urging upon them the necessity for demanding a clean milk supply, i.e. one from tuberculin-tested cows.

This matter is now being seriously taken in hand, and a Veterinary State Service is being formed, with a staff of whole-time men whose duties consist mainly of inspection of dairy cattle with a view to the formation of tuberculosis-free herds. A clinical inspection is made of the udders periodically, usually four times a year, and for the owner who wishes to ensure that his herd is completely free from tuberculosis the cows are tested with tuberculin—of which we now have a synthetic variety—and by the intradermal method which forms a much more delicate test than the former subcutaneous method. We have reason to hope that this newly formed Veterinary State Service is thoroughly justifying its existence and that it will prove of benefit not only to human beings, by getting rid of a source of tuberculous milk, but also to the dairyman and the agriculturist, by weeding out from his herds tuberculous cattle whose presence is always a source of danger. It is a common observation that the herds from which tuberculosis has been eliminated are much more resistant to other ailments—the services of the veterinary surgeon being less in demand than when this disease existed.

### *Mange.*

Mange of the horse is now dealt with in all parts of Great Britain and is compulsorily notifiable under a Mange Order issued from the Ministry of Agriculture and Fisheries. Its spread has been effectually checked, and although it is not yet completely eradicated, the number of cases in the horse is now extraordinarily small. It is, however, to the domestic pets, especially the dog and cat that attention should be drawn, for it is quite an easy matter for a pet dog to transmit the parasite of mange from itself to its owner. An itchy dog should, therefore, always be regarded with suspicion, and the pernicious habit of allowing a dog to sleep in bed with a human being should be emphatically discouraged.

A dog with mange, especially in hot weather, or when its body becomes heated by lying in front of the fire (or sleeping on an eiderdown or blanket), will be continually scratching, especially in the region of the armpits and under the thighs, where the body is hot and the hair is thin. If no treatment is adopted, the dog will break out in sores, the hair will fall off, and the animal will presently smell very offensively and become covered with scabs. If allowed to come into contact with any part of the human body for more than a few minutes, it is quite an easy matter for the parasite to transfer itself to its human host, and it may remain for a considerable number of days, or even weeks, until it has finished its life-history. During this time it will give rise to a great deal of irritation and discomfort, which could easily have been prevented had the owner of the dog sought veterinary advice.

There are numbers of other diseases in which it is of value to the Public Health service that in the fight for their eradication the human physician and the veterinarian should collaborate, for the patients of each are equally attacked. Cancer may be taken as a type. This dreaded disease is recognized in such veterinary patients as horses, cattle, dogs, cats, and even fish, and many of the theories which research workers form, if their observations are concentrated on man alone, may at once be seen to be erroneous upon comparing notes with veterinary pathologists, whose lives bring them in contact with the comparative aspect. In foreign countries this has been for a long time recognized, and their governments have granted liberal funds for research into the problems of animal diseases and their relation to Public Health, finding it a paying proposition, even if considered only from the economic standpoint. Great Britain has been behindhand in this respect, but during the past few years with the establishment of the Animal Research Institute connected with the Royal Veterinary College, at Camden Town, and of the Institute of Animal Pathology at Cambridge, together with the creation of University Veterinary degrees and a Post-Graduate Diploma of Veterinary State Medicine, there is a good prospect that, long before another decade has passed the Government organization of Veterinary Officers of Health will have as important a place in Public Health as is accorded to the graduates of the human branch of state medicine.

My list of those diseases which furnish valuable instruction in the epidemiology of animals and man is by no means complete, but I must in conclusion just allude to one other—namely contagious abortion of cattle—which gives rise to Undulant Fever of man. That cases of transmission from the cow do occur is generally admitted, but not as frequently as might be expected when one considers the great prevalence of this disease in milking cattle. In connection with milk too as a food product one must not forget to draw attention to its danger as a carrier of disease in such diseases as scarlet fever and diphtheria of man.

In conclusion I think that you will agree that I have introduced sufficient framework in the brief time at my disposal to illustrate the importance of consideration of the inter-relationship between the diseases of animals and man.

G. S. THAPAR, Lucknow.

Animals have long been associated with man and their domestication has naturally led to the transmission of their diseases to man. The various diseases thus transmitted may be caused by bacteria, protozoa, worms and insects. The speaker proposes to deal with *only* those diseases that are due to worms (helminths) and thus the responsibility of the domestic animals in the spread of helminthic infections in man is indicated.

For convenience, the subject is considered under three categories thus:—

1. The helminths which are of common occurrence as adults, both in animals and in man.

2. The helminths that occur as adults in man, but as larvæ in animals.
3. The helminths that occur as adults in animals but as larvæ in man. Such cases are only accidental.

Instances are given under each and it has been shown that animals are important in the transmission of helminthic infections in man. The mode of their transmission is also discussed and an emphasis is laid on the rôle of domesticated animals and pets and also on the reservoir hosts in this connection.

The methods of control of the helminthic infections are discussed and the difficulties in the adequate control of helminthic infections in animals are pointed out. It is also shown how a helminthologist is necessary in the discovery and subsequent eradication of the diseases of helminthic origin. The value of meat inspection, which is so inadequate at present in India, is also emphasized.

In view of these facts, it is suggested that there should be greater co-operation between the medical and the veterinary investigators and between both these and the zoologists. The latter would, as is apparent from the work in the past, be able to help them in the solution of many of the intricate problems associated with the helminthic infections of man and domestic animals. This is indicated further by the organization of the Institute of Agricultural Parasitology under the direction of Professor R. T. Leiper at the London School of Tropical Medicine.

## XXIV. RIVER PHYSICS IN INDIA.

*(Sections of Mathematics and Physics, Geology, Geography and Geodesy, and Agriculture, in co-operation with the National Institute of Sciences of India, and the Indian Physical Society.)*

1. PROF. M. N. SAHA presided and opened the discussion.

2. MR. D. N. WADIA, Calcutta.

*Changes in the courses of Indian rivers during the latest geological epoch.*

Few changes in the physical geography of India during historic times and in the Sub-Recent geological age have been so well proved as changes in the river-systems of Northern India. Those changes in the number, volume and direction of the chief drainage-lines—in some instances amounting to a complete reversal of the direction of flow of a principal river—can be classified :—

I. Prehistoric—the change of a great north-west-flowing river of early Pleistocene time from Assam to Punjab and Sind, which carried the combined waters of the Brahmaputra, Ganges and Indus, to the present hydrographic system of Northern India (*Indobrahm*).

II. Changes during historic times—

A. In Punjab and Sind :—

(1) The *Sarasvati river* of Vedic times, the 6th river of the Punjab, becoming the Jumna tributary of the Ganges in the days of Manu.

(2) The well-known lost river of the Punjab (*Hakra*) over 600 miles long, which up to the 10th Century flowed from

Himalaya to the Rann of Cutch (then an inland sea) through the *Eastern Nara*—the Hakra was probably a deserted bed of the Sutlej, which up to the 13th Century flowed independently of the Indus, without joining the Beas.

(3) The migration of the channels of the Beas, Sutlej and Chenab through the Punjab plains.

(4) The obliteration of the Sind Gulf by southward encroachment of the Indus delta, building the plains of Sind by the oscillation of the Lower Indus.

(5) The present Soan valley, a mis-fit, the sole remaining portion of the Indobrahm.

B. In Bengal :—

(1) The rapid southward extension of the Gangetic delta during the last 5,000 years from its head in the Rajmahal hills and Sylhet lagoons.

(2) The diversion of the Brahmaputra to the east of Madhupur and its later deflection again to the west.

(3) The oscillation of the Ganges and Brahmaputra channels during the last few centuries and the easterly growth of the delta.

(4) The deflection of the Teesta from its confluence with the Ganges to the Brahmaputra.

3. DR. SUNDER LAL HORA, Calcutta.

*Changes in the drainage of India, as evidenced by the distribution of freshwater fishes.*

The author directs attention to the various modes of dispersal of freshwater fishes and points out that they constitute an important group for the elucidation of palaeohydrographical problems. The occurrence of the Dipnoan and Ganoid fishes in the Upper Gondwana Beds of Kota-Maleri shows the position of the main river of the Mesozoic period. From the past and present geographical range of these ancient fishes some idea is given of the probable drainage pattern of India of those times.

The greater part of India proper of the Eocene period is now covered by the Deccan trap which has obliterated the channels forming the drainage of India during that age. Some evidence of the location of the main drainage channels is, however, furnished by the fish-remains found in the infra-trappean beds at Dongargaon. Dhamni and Phisdura and the inter-trappean beds at Takli, Pahadsingha, Deothah, Kheri and Kateru. From the situation of these beds it is inferred that the main drainage channels of the Eocene period were, more or less, in the same position as those of the Mesozoic epoch. From the nature of the fish-fauna it is clear that the sea was not far removed from the trappean beds of the Central Provinces. Attention is also directed to the fact that a predominantly Ganoid fauna of the infra-trappean period was, more or less, replaced by the modern bony fishes during the inter-trappean periods.

As practically all the principal genera of bony fishes had already appeared during the Tertiary, further changes in the drainage of India are adduced from the geographical distribution of the modern fishes. The orogènic movements that gave birth to the Himalayan chain of mountains produced a succession of changes in the drainage pattern of India. The distribution of fishes shows that for a considerable time the longitudinal basin formed as a foredeep at the base of the Himalayas served as the main drainage channel. This channel was discovered by Pascoe and Pilgrim simultaneously and designated as 'Indobrahm' or 'Siwalik

River' respectively. This river is believed to have flowed from east to west and carried the combined waters of the Brahmaputra, the Ganges and the Indus. In the author's opinion its headwaters were probably in Southern China, and in support of this contention several instances are cited from the distribution of allied genera of fishes.

Certain localized orogenic movements resulted in the dismemberment of the 'Indobrahm' into at least three drainage systems, the Brahmaputra, the Ganges and the Indus. In this process the once continuous fish-fauna became segregated into definite regions. A detailed study of some of the elements of this fauna shows that the Brahmaputra portion was the first to be separated and that the Ganges and the Indus flowed together as a combined river for a considerable time afterwards. The fish-fauna of the Ganges and the Indus are almost identical and this would indicate that the two rivers probably became separated, geologically speaking, not very long ago. Attention is here directed to the fact that the Jumna river, a tributary of the Ganges, was a tributary of the Sutlej within historic times.

One remarkable fact of distribution of Indian freshwater fishes is the close similarity between the fauna of the Eastern Himalayas and that of the hills of the Peninsula in the extreme south. This is explained in terms of the geological changes that may have occurred at the time of separation of the Brahmaputra from the 'Indobrahm' of the Tertiary period.

The probable mode of evolution of the present-day drainage pattern of the Himalayas is discussed and evidence is adduced to show that it has developed from a consequent drainage, e.g. rivers draining north and south of the crest.

The fish-fauna of India is probably derived from that of Southern China and Indo-China and its transference towards the west and south appears to have been facilitated by longitudinal valleys, river-captures, etc. In South-Eastern Asia the southern and western portions appear to have been sinking and this has made the north fauna migrate towards south and west. The present-day distribution of fishes strongly supports such a hypothesis. The eastward flowing rivers of the Peninsula probably assumed their present direction after the rise of the Western Ghats; their antiquity is apparent from their broad valleys.

Another fact of fish distribution, to which reference is made, is that of the large carps of India and several other species which are not found south of the Kistna river. From this certain inferences are drawn regarding the probable drainage of the Peninsula.

4. MR. C. C. INGLIS, Poona.

*The use of models for elucidating flow problems based on experience gained in carrying out model experiments at the Hydrodynamic Research Station, Poona.*

Hitherto it has been customary to talk of hydraulic model experiments in general terms, as though only one type existed; and then, either to accept the results as being directly applicable to the prototype or else as only a guide, or even as giving results of doubtful value.

As recently as December, 1935, Herbert D. Vogel, at that time Director of the U.S. Waterways Experimental Station at Vicksburg, after asking information from 50 laboratories or individuals engaged in hydraulic research, stated: 'With a few notable exceptions, the replies contributed scarcely any information directly pertinent to the subject.'

In this Paper the 8 main types of models are described with examples showing why some types present little difficulty and give results suitable for immediate application whereas other types, especially those relating to alluvial rivers, present very great practical difficulties.

*Types of models :*

I. Models which are geometrically similar in shape to the prototype and give geometrically similar results.
II. Models which are geometrically similar in shape ; but do not give geometrically similar results.
III. Regime models, in which conditions of flow are maintained constant, with complete freedom as regards silting and scouring.
IV. Combined erodible channel and rigid models.
V. Rigid and semi-rigid vertically exaggerated models in which conditions are imposed, e.g. tidal models.
VI. Models with mobile protection—falling aprons, spurs, protection round piers, etc.
VII. Meandering river models.
VIII. Combined rigid, mobile and meandering river models.

Geometrically similar models in which parallel flow or free vortex flow are established give geometrically similar results provided they are not too small to make it possible to reproduce the boundary conditions of the prototype. In other cases similarity is not attained.

Channels may be divided into two classes :

(*a*) Channels flowing within rigid boundaries;
(*b*) Channels flowing in incoherent alluvium.

In the former, flow is under flumed conditions and a heavy super-charge of silt can be carried provided the slope is sufficiently steep. In the other type, flow is 'natural', adjustments to changing conditions being brought about by scouring and silting. Lindley, in his Paper on 'Regime channels', Punjab Engineering Congress, 1919, put forward the original theory that 'the dimensions, width, depth and gradient of a channel to carry a given supply loaded with a given silt charge were all fixed by nature' and some ten years later Gerald Lacey, in his paper on 'Stable channels in alluvium', *Procs. of Inst. C.E.*, Vol. 229 (1929-30), produced a series of formulæ which fixed gradient and shape of regime channels. These formulæ have gradually been winning acceptance all over the world.

According to Lacey, $P = 2{\cdot}67\sqrt{Q}$, a formula which is now generally accepted, from which it follows that $P/R = 7{\cdot}12\ V$, where $P$ = wetted perimeter; $Q$ = discharge, $R$ = hydraulic mean depth, and $V$= velocity. This is the Lacey 'shape formula'. According to Lacey's 'initial regime formula' $V = 1{\cdot}17\sqrt{fR}$, where $f$ is the silt factor, which is proportional to $V^2/gR$, the Froude number. So, on the assumption that a regime channel approximates to a semi-ellipse, with the semi-circle as the limiting shape, $Q_{\text{lim}} = 1{\cdot}82/f^2$. Actually, however, for reasons explained in the paper, $Q = 3{\cdot}2/R^2$ is the minimum discharge with which it is safe to work.

1. From the Lacey formula and from Nikuradsa's work on roughened pipes it follows that the finer the silt, the larger the discharge required in the model.

2. There is a natural regime silt charge, which varies with the discharge and silt grade and there is a minimum velocity for each silt, below which the regime silt charge cannot be carried.

3. For the same grade of silt the lower the discharge the more sensitive is the model to a super-charge of silt.

The regime conception must form the basis of all accurate model work dealing with movement of silt, and its division between off-takes.

4. Experiments with *combined erodible channels and rigid models* present difficulties because the flow formula is different in the two parts and hence a model which is identical in plan in model and prototype cannot give similar results. In many cases this can be overcome by

fitting. Part of the difficulty is due to the fact that though vertical exaggeration has been adopted as common practice in model work, lateral exaggeration, which is also natural has, so far as the author can determine, been overlooked.

5. One of the best known types of models is the 'tidal model', which falls under the semi-rigid model type. In this, conditions are imposed, the sides, and in many cases a considerable part of the bed, being held against scour. Such models give valuable results provided they are correctly designed; but the fact that conditions are imposed must not be overlooked. Rigid models are used in America for determining the effect of 'cut offs' on upstream water levels and they give valuable information as to the immediate effect on water levels upstream, but that is all. Models with mobile protection, e.g. falling aprons, pier protection, etc. give geometrically similar results of great value.

6. Combined rigid, mobile and meandering river models present many difficulties, because the laws governing each of the three types, here combined, are different. To solve such problems, experiments to determine the scale effect of various factors have to be carried out in separate models and the results of these applied in the large, full length model. Even in a very large model, though accurate results for full supply discharge can be obtained, with low supplies difficulties arise in reproducing scour in the model.

7. The main fact which follows from this paper is the importance of large models; and at Poona the discharge now preferred ranges between 6 cusecs and 15 cusecs in each model, but may be as much as 30 cusecs in a single model.

Although in general the larger the model the better the results, it must be remembered that doubling the size of a model quadruples the area, the discharge and the labour involved; and increases the time factor to approximately 1·6 times.

8. The general conclusion is that in competent hands, a very wide range of experiments with large models gives results of high qualitative accuracy and may also give quantitative accuracy; but in general the data available for river models is meagre and though the gaps in data can be filled to a large extent from field experience, so that a model can be made to reproduce what has previously occurred in the prototype under known conditions of discharge and silt charge, the problem which generally has to be tackled is what will happen if nothing is done or what should be done to prevent further damage.

The answer to this depends almost entirely on a capacity to foresee probabilities and possibilities and an intimate knowledge of the engineering side of the problem under consideration. Model experiments are, in fact, a very valuable aid in the solution of practical problems but success depends mainly on engineering skill, which they cannot replace.

5. MR. GERALD LACEY, Roorkee.

The author, dealing first with his subject historically, and with that branch of river physics which may be denoted the study of the behaviour of Indian rivers by the engineering profession, ascribes the origin of the science to the construction of the first major canals in northern India and Madras nearly a century ago. The construction of the canal headworks presented problems in the flow of water both in boulder and in sandy alluvium; the canals, which transported alluvium withdrawn from the rivers, drew attention, from their instability, to the phenomena of silt and scour.

The growth of communications and the construction of road and railway bridges founded on wells sunk in an alluvial bed enforced the investigation of allied problems. The author dates the modern study of river training and control from the publication of Sir Francis Spring's classic paper in 1903.

Early difficulties on canals, particularly in respect of the hydraulic gradient, were diminished by the successive publication of the flow formulas of Bazin and of Kutter: it was not however until Kennedy produced, in 1895, his empirical equation correlating the depth of a channel with the critical regime mean velocity that the foundation of alluvial studies was firmly laid.

Reference is made to the invaluable model experiments of Osborne Reynolds in 1888, and to the slow realization of their full significance.

The author draws particular attention to the phenomenon of exaggeration in the vertical scale of models. The necessity for this exaggeration, so frequently ascribed by the laboratory worker to the need for silt movement and of avoiding laminar viscous flow, arises from a feature common to all channels large and small. He refers to the invaluable data now made available from canal systems in India, and the manner in which such data fills the gap between the laboratory worker and the river engineer.

Reviewing modern developments the author shows how the earlier equation of Kennedy connecting the mean velocity and the vertical depth

$$V = mD^{\cdot 64}$$

can be replaced by the author's formula

$$V = kR^{\cdot 50}$$

involving the hydraulic mean depth. He shows further that the hydraulic mean depth and the slope are correlated by the equation

From the latter two equations he demonstrates, by recourse to the theory of models, that the wetted perimeter and the discharge are correlated by the simple expression

$$P \propto Q^{\frac{1}{2}}$$

a relationship that has been amply confirmed by statistical work in India.

The author quotes the equation derived by him

$$V = 16\ R^{\frac{2}{3}} S^{\frac{1}{3}}$$

applicable to flood conditions in alluvial streams, in which the rugosity is implicit in the depth and slope adopted.

The author shows how it is possible by the use of his equations to determine the scales for models with tidal or uniform flow, and indicates how the problem of the railway engineer, both in respect of scour and of waterway may be solved.

The author comments on the statement that in a regime channel the dimensions are uniquely determined by the discharge and silt grade, and emphasises how in Nature one of the variables may prove a constant and a dominating factor. He applies his equations to a study of flow in the boulder regions of rivers, and in the true alluvial plain, defines 'tortuosity' and 'meandering,' and discusses 'silt sorting' and 'attrition' as contributory factors to the known characteristics of rivers in their course from the foot hills to the sea.

The author holds, despite the complexity of flow in alluvial rivers, that ultimate knowledge of river physics must be based on normal or regime equations of the type formulated.

In view of the fact that in alluvial channels the bed is non-rigid, and moving slowly forward, the author deprecates the application of formulæ derived from pipes, in which the velocity distribution is patently of a very different order. As the author conceives the problem the normal cross section in alluvium closely approximates to a semi-

ellipse of which the water surface coincides with the major axis, the isotachs being confocal. The method of mathematical attack would be similar to that of Prandtl, the formulas should be different, and not far removed from those put forward by the author.

6. MR. KANWAR SAIN, Lahore.

*The effects of the construction of weirs and weir-controlled canals on the regimes of the Punjab rivers.*

This paper deals with the Punjab rivers only. 'Punjab' is a Persian compound word, composed of 'Punj' and 'Ab', meaning 'five' and 'waters' respectively. The first Aryan settlers knew this part of India as the land of the seven rivers (*Sapta* Sindhavas), consisting of the Saraswati, the Sutlej, the Beas, the Ravi, the Chenab, the Jhelum and the Indus. Saraswati is now a small river and discussion is confined to the other six rivers only.

An attempt has been made in the paper to summarize the results of an examination of the changes that have occurred in the regimes of the above rivers as a result of the construction of weirs and weir-controlled canals.

The examination was carefully made by a committee of two Superintending Engineers, one from the Punjab and the other from the Bombay Presidency, and consisted of a critical analysis of about 9,67,000 gauge readings actually observed and recorded since 1861.

Perhaps no other set of rivers in any other province or country provides such a wealth of information on this aspect of the 'River Physics'. This will be amply borne out by the fact that no less than 13 weirs have been built on the six Punjab rivers and that the total withdrawals from these rivers by weir-controlled canals exceed 1,50,000 cusecs.

The first effects that may be anticipated from the construction of a weir are :—

(*a*) the flattening of the slope of the river upstream, and

(*b*) lowering of the level of the water surface downstream, both due to the reduction in the amount of water passing below the weir and also to a degradation of regime levels.

The examination of levels over long periods, however, shows that after the construction of a weir on an alluvial river, the upstream slope tends to recover, and over a sufficient term of years will recover its former value; also that irrespective of reduction of discharge the levels downstream of a weir will, in a period which may extend to 20 or 30 years, recover and even rise above their former value, while specific levels show a greater rise.

It is also shown that the withdrawals of water from one river of an alluvial system produce sympathetic changes in the regime of another river joining it.

7. RAI BAHADUR A. N. KHOSLA, Jhang.

*Design of weirs on permeable foundations.*

8. DR. N. K. BOSE, Lahore.

*River physics laboratories of Europe and America.*

Of recent years conviction has been gaining ground among hydraulic research workers that there is a physics of river flow and as such it is possible to study river movements and the changes in the course of a river from scale models in a laboratory. Though the science of River

Physics has not attained to that stage of development as has been reached by the science of Nuclear Physics or any other branches of Physics, yet since the days of M. Fargue, Osborne Reynolds and Vernon-Hercourt the progress of this branch of Physics has been very rapid. The experiments of Prof. Gibson in England, of Engel, Winkel, Krey and Rehbock in Germany and of Freeman in America have proved conclusively that not only can scale models, properly conducted, give valuable indications for the training of a river, quantitative information can also be obtained from such experiments. In his tidal model of the river Severn Prof. Gibson has been able to reproduce the conditions of the river in 1927 starting with the river in 1848. Prof. Krey in his Elb model and Prof. Rehbock in the Rhine model have been able to get very good quantitative agreement between the model and the prototype. In the U. S. Waterways Experimental Station at Vicksburg Vogel has been able to reproduce various conditions of the river Mississippi in a number of models. In this paper it is proposed to deal with the various methods applied by different workers in developing their river models and also the amount of success they have attained in them.

9. Mr. S. C. Majumdar, Calcutta.

*River problems in Bengal.*

1. By far the major portion of Bengal is deltaic, having been built up by the silt carried by her rivers. Absence of marine deposits and presence of fresh water deposits up to a depth of about 1,300 ft. (no deeper borings yet made) seem to indicate that marine conditions never existed up to this depth. The soil composing the upper strata is, however, quite different from that of the lower strata and it appears that the upper delta that we find to-day consisting of blue clay and sand, has been built upon another older delta consisting of yellow clay and sand, which was depressed permitting of fresh deposits by the present river systems.

2. To appreciate the river problems in Bengal it is necessary to envisage how the rivers functioned and are still functioning in building the land and in raising and extending it towards the sea. Nature has been employing two agents in this task, *viz.* upland flood carriers and the tides. The former have been transporting the building-materials brought in by the rain washings from the catchment areas and, after building and raising the banks along their courses, have been discharging the balance into the sea. Portions of this get consolidated and extend the delta and the rest is dispersed by tidal current along the delta face and remain in an unconsolidated state. Tides while travelling inland pick up the latter almost to the saturation point and perform the same delta building functions as the upland flood carriers, with this difference, that, while the latter function mainly during floods, confined to the monsoon months, tides function twice daily during the whole year.

3. Nature again has been assisted in her task by two favourable factors, *viz.* the steep slope of the Himalaya, which has thus been able to furnish building-materials in abundance, and abnormally high tide level, which has facilitated the distribution of the materials. High tide level has also facilitated transport by water, and it can be truly said of Bengal that her rivers built the land, are draining and fertilizing it and are helping in transporting the produce. In areas where the rivers are still continuing these beneficial activities, as in Eastern Bengal, the country is healthy and prosperous, and where the rivers are deteriorating and these activities have been interfered with, as in Central and Western Bengal, the country is progressively deteriorating both as regards health and productivity of the soil.

River problems in Bengal are thus virtually the problems for Rural Development in Bengal and must be solved if this country, specially

her western and central parts, which used to be very healthy and prosperous even about a century ago, has to be prevented from reversion to swamps and jungles from which she was reclaimed by her rivers.

4. For a proper appreciation of these problems and their solution the rivers in Bengal, having regard to their different characteristics, may be classified as follows :—

Group I. Primary delta builders originating from the snow capped Himalayas, maintaining perennial flow and navigable. The principal rivers under this group are (1) the Ganges series, which by far is the most important delta builder, (2) the Brahmaputra series, which, after her connection with the Tsampo of Tibet and subsequent addition of the Teesta waters towards the end of the 18th century, is proving to be a formidable rival of the Ganges and (3) the Meghna.

5. Group II. Primary delta builders originating from the low hills of Chhota Nagpur and Santal Parganas, such as the Damodar, the Ajoy, the More, the Cossye and other Western Bengal rivers. These rivers are torrential and though they bring in enormous volumes of flood occasionally, they dwindle down to a mere trickle sometime even during the rains, while during the dry season there is practically no flow. Their contribution towards building up of the delta could not therefore have been much, as compared with that of the Ganges, though it seems that a portion of the eastern part of Western Bengal, which is deltaic, must have been built by these rivers, specially the Damodar and the Cossye. Their value, apart from the question of flood flushing, etc. which will be discussed below, however, lies in their being the only sources available for providing supplies urgently needed for artificial Irrigation, necessity for which is practically confined to Western Bengal.

6. Though the total monsoon rainfall as also its distribution during the earlier part of the crop period are normally sufficient, rain usually fails after the middle of September and the necessity for irrigation is felt in Western Bengal even in normal years. In years of abnormally low rainfall irrigation is urgently needed as an insurance against famine. Owing to the proximity of the catchment areas of these rivers to the areas to be irrigated, river supplies also fail when irrigation is required during periods of scarcity, and without storage it does not seem to be possible to meet the needs of irrigation on a large scale. Again, owing to heavy incidence of rainfall at times, the cost of diversion and cross drainage works is usually rather heavy, out of all proportion with the comparatively small area that could be irrigated by the widely fluctuating daily flow of these torrential streams. Storage works, by impounding during floods and supplementing the dwindling daily flow of the rivers during periods of scarcity intervening between floods, really function like a flywheel in an engine. They can thus enormously increase the irrigable capacity of a stream, especially as the stored water is needed for irrigation not so much in the transplantation season, when though a large amount of water is required the rainfall is usually sufficient, but in the latter part of the crop period when the requirements of crops is the minimum. Storage irrigation schemes are thus likely to be rather profitable undertakings in Western Bengal, and as no rain is usually expected during the dry season and rivers also practically dry up then, they provide the only means by which sugarcane and rabi crop could be grown in these parts. As most of the people live on agriculture irrigation projects supplemented by storage works constructed in the hilly valleys of these rivers of Western Bengal, mostly outside the province, are thus urgently needed for their economic uplift. So far two schemes of outstanding importance have been brought to light and investigated, viz. the Darkeswar Reservoir project and the More Reservoir project to irrigate about 200,000 acres by the former and 432,000 acres by the latter.

7. Group III. Subsidiary delta builders—mainly the lower reaches of rivers in Group I and II within tidal limits, which, apart from continuing the delta building activities along with these rivers, constitutes

very valuable assets by providing cheap transport by water of the produce of the country.

8. In all ancient accounts Bengal is reported to have been healthy and prosperous. About the middle of the 17th century Bernier wrote that Bengal was even richer than Egypt. Even about a century ago Hamilton found Western Bengal to be highly prosperous and gave Burdwan the first rank in the whole of Hindusthan as regards productive agriculture. This area is now one of the worst both as regards health and productivity of the soil. In the eastern parts of Bengal where the rivers are still continuing their beneficent activities, the country is healthy and prosperous. Even in the rest of Bengal there is no dearth of water resources, but the progressive deterioration in health and productivity of the soil, specially in the west and in the centre, is due to their faulty distribution. Through many a stream more water flows than is necessary causing disastrous floods, while at other places decrease in flow through natural waterways has caused serious deterioration rendering them even incapable of draining the country side. Indeed many of these streams, which were intended by nature to spill over the land which they traverse and keep it in health and plenty by supplying the rich silt of the Ganges, Damodar, etc., have now been converted into stagnant pools of water breeding mosquitoes, and many a district, specially in the centre and west, has been rendered extremely unhealthy with decreasing population and with land gradually going out of cultivation.

9. This faulty distribution of the water resources, which has been effected partly by human interference and partly by natural causes, constitutes the main river problem in Bengal. Nature has provided her with water resources in abundance and their equitable distribution is now vitally needed for the Rural Development. These problems will now be examined somewhat closely by dealing with these groups of the rivers separately and examining a representative type of each group in detail.

*Rivers of Group I.*

10. The areas which have been adversely affected mainly due to natural causes, i.e. by changes in the courses of rivers, are :—

(1) Central Bengal due to diversion of the Ganges through the Padma towards the beginning of the 16th century.

(2) Northern Bengal due to diversion of the Teesta through her present course towards the end of the 18th century and

(3) Portions of Mymensing District due to the diversion of the Brahmaputra through the Jamuna channel soon afterwards. There is no controversy as regards the last two changes as they occurred comparatively recently and can be definitely proved by Rennel's maps. Even as regards the first it was taken to be an established fact hitherto; but as this theory has recently been challenged by late Sir William Willcocks I propose to examine this question in detail and take up the Ganges as the typical representative to illustrate the problems arising from this group of rivers.

11. According to Sir William the Bhagirathi and other rivers in Central Bengal were, originally, really canals excavated by the old Hindu Rulers of Bengal. But the following considerations will show that this theory is absolutely untenable.

Large extension of the delta towards the west as compared with that in the east can only be explained by the fact that the main volume of the Ganges flood must have passed down the Hooghly and the contiguous estuaries just to the east for a much longer period than along the present course, unless it can be shewn that there was another delta builder serving the western side of the delta with flood discharge even larger than that of the Ganges, Brahmaputra and the Meghna combined. No such delta builder exists to-day nor could they have possibly existed

in the present geological epoch, as the combined catchment area of all the rivers of Western Bengal does not exceed 25,000 sq. miles as compared with 397,000 and 361,000 sq. miles which are the catchment areas of the Ganges and Brahmaputra respectively. There are also other religious, traditional and historical evidences as given in the main paper in support of the established theory that the Bhagirathi constituted the main channel of the Ganges till the 16th century when —and this is a natural characteristic of the deltaic rivers as explained in the main paper—the Ganges diverted along the present Padma channel.

12. Central Bengal has really been built up by the Ganges which, in the olden days, used to distribute her waters through the Bhyrab, probably the easternmost branch, and the Bhagirathi which again trifurcated into three branches at Triboni -the Bhagirathi, the Jamuna and the Saraswati. As a consequence of the diversion both the latter branches as also the Bhyrab are now dead. Two other spill channels, the Jalangi and the Mathabhanga, opened up comparatively recently, but they are also dying and get completely cut off from the Ganges during the dry season. Even during the monsoon they can no longer draw enough water from the Ganges to feed their distributaries, which used to distribute equitably the Ganges flood over the whole area and which, in consequence, are now mostly dead. Only the Bhagirathi is now more or less active in the lower reaches thanks to the occasional floods that she receives from the rivers of Western Bengal and to the tidal flushing and other conservancy measures of the Calcutta Port Trust But in her upper reaches she remains cut off from the Ganges except during the rains when she gets only a mere fraction of her former discharge. In her lower reaches also she is gradually deteriorating and additional supply of upland water is urgently needed not only in the interest of Calcutta as a port but also for her drinking water supply, to arrest the gradual advance of the salt water limit up the Hooghly.

13. Solution then lies in the restoration of the Ganges spill as far as possible through the three principal channels, the Bhagirathi, the Jalangi and the Mathabhanga. As hydraulic conditions are now much more favourable down the Padma channel, the point to be considered first is whether sufficient quantity of spill could at all be extracted from her and diverted through these channels for flushing Central Bengal without a barrage, the cost of which will of course be prohibitive, and without waiting for an indefinite period till nature, after raising the present spill areas in Eastern Bengal, turns her attention again to Central Bengal Having regard to the characteristic of deltaic rivers, this latter contingency is probable, but the present condition of Central Bengal as regards health and productivity of the spill is so deplorable that unless the area could be flushed by the Ganges spill in the near future the area will revert to swamps and jungles from which it was reclaimed by the Ganges in the olden days.

14. These spill channels from the Ganges pass through successive phases of deterioration and improvement, depending on the position of the off-take with reference to the main channel. The present position of these off-takes, specially that of the Mathabhanga, is definitely improving as the huge char that hitherto marked this off-take has been washed away due to changes that are taking place in the regime of the Ganges. But mere improvement of the off-take is not sufficient. To be able to fully utilize this natural tendency to our advantage the carrying capacity of the channel as also that of the outlets have to be improved, so that the increased discharge that could be drawn due to the favourable position of the off-take could be efficiently disposed of.

15. This again is not enough. Unless these channels are allowed to spill over their banks a good portion of the silt content of the flood entering them, which the reduced velocity due to flatter gradient in their lower reaches is unable to transport, they will naturally deposit in their beds and the channels will again deteriorate. Dredging, though neces-

sary initially to increase their carrying capacities, cannot be relied upon to maintain these channels permanently, for, apart from cost, spoil bank will, within a few years, reach a height beyond the lift of dredgers. Apart from its necessity to improve the health and productivity of the soil, extensive land spilling during floods, therefore, seems to be an essential requirement even for maintaining these channels in deltaic Bengal, which carry such a large proportion of silt. To what extent land spilling may be technically and practically possible can only be ascertained after a contour survey, as there are large vested interests which may be adversely affected by the flooding, necessitating the requisite protective measures. But there seems to be no doubt that in the lower areas which have been prematurely reclaimed, the present method of cultivation will have to be changed, necessitating the introduction of a substitute crop, which can be harvested before the Ganges begins to rise in August, or East Bengal paddy which grows with rise in the water level.

*Rivers of Group II.*

Primary delta builders originating from the Chhota Nagpur and Santal Parganas hills.

16. Problems of these rivers with reference to artificial irrigation needed in Western Bengal have already been dealt with. Thanks to human interference with their beneficial activities these rivers have, however, presented rather unique and complex problems which will now be considered. The area affected has been built up by them and is flat. But before it could be raised sufficiently by silt deposit during flood flushing it was prematurely reclaimed by flood embankments. But owing to inefficient maintenance breaches were frequent. The land could then get occasional flushings and it did not deteriorate in those days so seriously as it has done now. For more efficient maintenance most of these embankments were gradually taken over by Government and in consequence the breaches are now rare and even when they occur they are closed immediately thus depriving the land even of those occasional flushing of the earlier days. The result has been that the net work of spill and drainage channels within the enclosed area are now dead and can no longer function even as drainage channels. In fact, their beds have also been cultivated at places and they have been converted into stagnant pools of water breeding mosquitoes. In consequence the area is progressively deteriorating in health and productivity of the soil, and land is gradually going out of cultivation.

17. Again the floods being unable to spill are depositing a portion of their silt content within the river channels, thus raising their beds, and as the protected areas, instead of rising by silt deposit, are probably getting gradually lowered due to surface washings caused by the local rainfall, drainage by gravity is becoming more and more difficult and in some areas it has already become impossible. The flood level is also rising necessitating higher and higher embankments and increasing the potential danger to life and property by concentrated discharge through breaches, which can hardly be avoided in earthen embankments subjected to high pressure of sudden floods of these torrential rivers. In fact the position is very serious and unless a bold policy of improvement is followed in the near future—delay will make the solution more and more difficult—these embanked areas of Western Bengal will gradually revert to swamps and jungles from which these were reclaimed prematurely by man.

18. The ideal solution will no doubt be to restore the old condition by the removal of the embankments. Where practicable this solution should certainly be adopted. This will no doubt inundate the area occasionally during floods. But the depth of inundation will be much less than what is now caused by concentrated discharge through breaches, while there will be no danger to life and property, as the removal

of the embankments allowing the flood to spill over a large area, will automatically lower the flood level. The floods of these torrential rivers also do not last more than a few days at a time and will increase the outturn of crops by fertilizing the land with the rich silt carried by these rivers. In years of exceptionally high floods or when floods occur before the seedlings have taken root into the soil, crops will no doubt suffer but this occasional loss will be more than counterbalanced by the increased outturn in normal years and by the improvement in health.

19. But in many cases owing to large vested interests such as railways, towns, etc., protected by these embankments as, for instance, in case of the Damodar left embankment, it is now hardly practicable to adopt such an ideal solution. Here we must be satisfied with the nearest practical approach to this ideal solution, i.e. water should be drawn through controlled escapes to be constructed at suitable places in these embankments and utilized in giving a copious flushing to the starved land during floods. One such project is now under preparation for irrigating and flushing an area of about 3,50,000 acres protected by the Damodar left embankments in the Burdwan, Hooghly and Howrah districts and there is room for a good many more similar schemes.

20. But though such schemes will probably find a solution to the sanitary and agricultural problems created by these rivers due to human interference with their natural activities, they will offer no solution to the rather serious problem with regard to their maintenance. This problem, which is becoming more and more serious owing to the delay in finding a solution, has been examined somewhat in detail in the main paper, taking the Damodar as a representative type of this group of rivers. To protect the area on the left bank, with large vested interests, from the disastrous consequence of frequent breaches through the left embankment of the Damodar, the right embankment was abandoned sometime in the middle of the last century. But this very fact, by raising the right bank by annual silt deposit, has now made an avulsion of the Damodar, with the maximum flood discharge of about 6½ lacs cusecs, through the left bank towards the Hooghly, a very probable contingency. Such an avulsion will of course be a disaster of the first order, for, apart from damage to vested interests on the left bank, the important city of Calcutta and the large business interests on the Hooghly will be in danger as this channel in her present condition cannot possibly carry even a material portion of this discharge.

21. Uncontrolled escapes towards the left are of course out of the question, and even controlled escape of a material portion of the Damodar flood, sufficient to afford a relief, has to be ruled out for the above reasons, apart from the question of prohibitive cost of the necessary work. As it is neither possible to increase the capacity and maintain the channel by dredging, the only feasible alternatives seem to be either to construct flood moderating reservoirs in the hilly valleys or to provide an escape through the right bank into the Rupnarain.

### *Group III. Tidal rivers.*

22. The lower reaches of the rivers of Groups I and II are tidal, and apart from discharging drainage and other beneficent activities, they perform the important function of carrying the produce of the country. Where these activities have not been interfered with by acts of man they are still discharging those functions, though, being now deprived of the supply of upland water, these tidal channels in the southern portion of Central Bengal are gradually deteriorating and will ultimately cease to function, except perhaps as regards drainage, as soon as the spill areas have been raised to near about the high tide level. But where man has interfered by prematurely reclaiming the spill area of these channels by means of embankments the position has already

become rather serious as, while these areas have remained low, the channel bed has risen by silt deposit making drainage by gravity already impossible in many cases. A distinction should be drawn in this connection between an upland flood carrier and a tidal channel. As the upland flood must be disposed of ultimately into the sea, when the former deteriorates it changes its course and its beneficent activities are not lost to the country, only they are transferred elsewhere. When however a tidal channel deteriorates it dies in its own bed and its beneficial activities are lost to the country. Thus the death of these tidal channels will mean that the only agents now left by nature for raising the tidal portion of Central Bengal will be lost to the country for ever. It will then be impossible to drain the area by gravity which will gradually revert to swamps and jungles from which it was prematurely reclaimed.

23. Solution lies in removal of the marginal embankments and other obstructions so that these areas may be adequately raised before they are reclaimed. But though this will certainly prolong their life it would not be sufficient to preserve these tidal channels permanently as carriers of the country's produce nor to arrest the rapid advance up the delta of the salt water limit, for which purpose a supply of upland water seems to be essential. As this point is not usually understood, physical characteristics of tidal rivers are explained in the main paper establishing the fact that to maintain the life of a tidal river additional supply of water is required to reinforce the flushing during ebb, which, without this reinforcement, is unable to clear the bed completely of the silt deposited during flood tides. As the supply given by the local drainage can be counted upon only during about five months of the monsoon, and the supply from the spill area will gradually disappear as this area rises by silt deposit, the only means of preserving the life of a tidal channel permanently is by providing a supply of upland water. Improvement of the spill channels of Central Bengal and diversion of a portion of the Ganges water thus seem to be necessary even for maintenance of these tidal channels.

24. The life-history of the Bidyadhari is given in the main note to illustrate these points. The history is reconstructed on the basis of indisputable evidence left by nature in her banks. These natural banks just above Bhangore Canal are found to be much higher than the tide level and must therefore have been built up by the upland floods; and the width between crests of these banks must give a rough measure as regards the volume of such floods which the Bidyadhari used to receive in the olden days. It appears from these and other evidences, as explained in the main paper, that the Bidyadhari was an important spill channel of the Jamuna and when this river was active, she used to draw a considerable volume of upland floods for her sustenance. After the diversion of the Ganges and subsequently of the Damodar the Bidyadhari was deprived of the supply of upland water and began to deteriorate.

25. But the existence of the vast spill area in the salt lakes should have enabled her to continue her beneficent activities, including the raising of the salt lakes, thus removing the nuisance so close to Calcutta, and the disposal of Calcutta's drainage, but for the acts of man. These acts were the premature reclamation of the land on both banks of the Matla and the Bidyadhari by means of marginal embankments as also the fisheries in lower areas interfering with free spill, the discharge of solid sewage and lastly the construction of the Kristopur Canal. The Bidyadhari is now absolutely dead beyond any chance of revival and the serious problems that have been created as regards drainage of areas near about Calcutta should serve as an object-lesson to those who are interfering with these tidal channels. In fact the Peali is also fast deteriorating and will soon share the same fate with the Bidyadhari, and immediate steps are necessary to prolong the life of this river to save a large portion of the 24-Parganas District, now served by this

river, from reversion to swamps and jungles from which the area was prematurely reclaimed by man.

26. Another problem that is gradually becoming more and more difficult with the deterioration of the tidal channels in Central Bengal is in regard to the valuable services which the rivers of groups I and III are rendering by providing a cheap means of transporting the country's produce by water. Together with Eastern Bengal, the tidal portion of Central Bengal possesses an important asset in the magnificent waterways. The principal highways—the Ganges, the Jamuna, and the Meghna —which connect Bengal with the neighbouring provinces of Bihar and Assam, need very little attention, and during the rains when the country is inundated goods from almost every village in Eastern Bengal can be carried by water to these principal highways and through them to the different trade centres including Calcutta. But a good portion of the discharge of the Ganges is being intercepted by the upper provinces for purpose of irrigation, and it seems necessary to watch those developments and adopt necessary measures, as further interception of the Ganges discharge during dry season is likely to adversely affect not only the prospective scheme that may be taken up for the improvement of Central Bengal but also navigation through the Ganges.

27. But the main problem that we have to face at present is with regard to the feeder channels connecting those principal highways, specially with Calcutta. During the earlier period of British Rule the Bhagirathi, the Jalangi and the Mathabhanga were being utilized as feeders from Calcutta to the Ganges, though even in those days there were difficulties of navigation during the dry season and various attempts were made to keep the Mathabhanga navigable throughout the year. As this was found to be more and more difficult the Calcutta Canal route to the east through the Sunderbans was opened early in the 19th century and gradually improved. These works, however, were intended for boat traffic but steamers, when they came into the picture, were following the route via Tolly's Nullah (excavated in 1770), the Bidyadhari, the Matla, etc.

28. Owing, however, to the death of the Bidyadhari, and consequently of the Tolly's Nullah, the steamer route through the Sunderbans is being shifted more and more towards the seaface. Here again nature has helped us by providing cross connections between the north-to-south delta builders. An explanation has been given in the main paper regarding the origin of these cross channels which are found to be so very valuable in the interest of navigation. But, owing to tides entering from both ends and meeting within the cross channel, thus gradually deteriorating it by dropping of silt, many of these channels have disappeared throwing the steamer route more and more towards the sea. In fact our main problem at present in respect of waterways for navigation is with regard to the maintenance of these cross connections, though the maintenance of the north-to-south channels in Central Bengal is also proving to be difficult and, in the purely tidal areas, will be impossible ultimately, unless steps are taken for a supply of upland water as already discussed while dealing with these rivers under group III.

29. The rivers of group I are also presenting a problem which is really inherent in the very nature of delta builders passing through very friable soil, as in Eastern and Northern Bengal, in the shape of erosion of their banks, and it is being aggravated by the natural tendency to concentrate all available flow through the two principal channels, the Ganges and the Jamuna. Diversion of portions of this flow through Central and Northern Bengal, as discussed above, will mitigate this problem to a certain extent.

30. In conclusion it may be mentioned that the all-important factor which dominates the river problems in Bengal is the large proportion of silt carried by the flood. As will be seen from the above (more fully dealt with in the main paper) though silt has proved to be one of our greatest benefactors, in some respects, it has also been a malefactor, and we

ought to make the closest study of this all-important factor. Beyond general knowledge as indicated above we, however, possess very little information on the subject. What is required is a Research Officer with a fully equipped laboratory to study this and other questions amenable to laboratory treatment, thoroughly and scientifically to guide us in our effort to solve the rather complicated river problems in Bengal. Many of these problems are unique without any parallel. Practices followed elsewhere will not therefore help us much but we have to find a solution ourselves by long and concentrated study of the local conditions.

10. PROF P. C. MAHALANOBIS, Calcutta.

*River floods in Orissa.*

The Orissa delta is a long narrow strip of alluvial land with an average width of about 40 or 50 miles. The total area is about 8,000 sq. miles, of which 2,300 sq. miles drained by the Mahanadi and 800 sq. miles by the Brahmani and Baitarini are especially subject to serious floods during the monsoon season. The Mahanadi has a total course of 500 miles with a drainage area of 50,000 sq. miles, and a maximum flood discharge of two million cusec. The drainage area of the other rivers is about 20,000 sq. miles.

About four-fifths of the annual precipitation is concentrated within the four monsoon months. Analysis of rainfall records do not reveal any appreciable seasonal or cyclic trends, so that the rainfall régime may be considered to be fairly stable. The areal distribution and frequency of occurrence of different intensities of rainfall from one to ten consecutive days have been studied in detail and furnish basic hydrological data for schemes of river control.

Analysis of daily heights of the rivers do not reveal any evidence of progressive deterioration of the channels. Frequency distributions of river heights from one to ten consecutive days have been prepared from which the actual risk of floods of any given height can be obtained with precision. The frequency of occurrence decreases in logarithmic proportion up to a certain definite height of the river which probably represents a critical transition state of the hydrological system.

Floods are caused by the heavy rain given by storms and depressions from the Bay of Bengal which move across the delta and the river basins roughly in west-north-westerly direction with an average velocity of 8·5 miles per hour, and which remain within the catchment area for about two days. The rainfall in the period immediately preceding a serious flood usually occurs in a well-marked patch of very heavy rainfall of over one inch per day for three consecutive days followed by moderately heavy falls for two or three days more. Heavy rain first occurs in the delta, and then in the more westerly portion of the basin. It therefore takes some time for the flood water to reach the delta. The crest velocity is about four miles per hour, and usually there is a lag of about three or four days between the maximum rainfall in the basin and the maximum flood at Naraj. Usually the river rises for three or four days, beginning to fall slowly from the fifth day.

The river channels in the delta are quite inadequate in their present condition to carry the flood water which in the case of a severe flood may amount to twice the capacity of the channels. Local rainfall in the delta by itself cannot cause a flood of importance but such rainfall can seriously aggravate the situation by increasing the intensity or duration of the flood.

Correlational studies showed that on an average the level of the Mahanadi rises by about 20 feet for an increase of one inch of average rainfall over the whole basin. The connexion is however not sufficiently close to enable individual forecasts being made in time to be of practical use.

Correlation between gauge readings at Naraj (near Cuttack) and at Sambalpur is very high, and it is possible to predict the height at Naraj within a few inches from twenty-four to thirty-six hours in advance.

In the case of the Brahmini similar correlational studies show that the condition of the river channel has remained more or less the same during the last 30 or 40 years, so that there is no evidence in support of the theory that the bed of the Brahmini was suddenly raised by two or three feet after the severe flood of 1926.

Normal monsoon precipitation in the catchment basin is of the order of 900 kilo-cusec per day while the rainfall intensity in the delta itself is only 30 kilo-cusec. Most of the flood water is therefore brought down by the rivers. During the monsoon the river emerges from the hilly country with high velocities and heavily laden with silt. On reaching the plains the velocity is suddenly reduced and the silt is deposited on the river-beds. The bed of the river rises in consequence and forms a shallow ridge on the summit of which the river flows. Gradually the bed is raised so high that the river bursts its banks and sends out branches. Fresh ridges are formed by the deposit of new silt, and the whole process is repeated over and over again. In this way the Orissa delta has become covered by about 15 main branches with innumerable minor streams within a distance of 40 or 50 miles.

Along the sea-coast of Orissa there exists a steady northward littoral sand drift which tend to form bars across the mouth of the river from south to north. The rivers are continually trying to form new land by deposit of silt, but this silt is continually being forced towards the north by this littoral drift. This is a peculiar characteristic of the Orissa coast, which explains the fact that the head of the delta is situated only 40 or 50 miles from the coast line whereas in the case of the Ganges or the Indus they are about 400 miles from the sea. Conditions in the Orissa delta are at present in a kind of dynamic equilibrium.

The escape of flood water is seriously obstructed by embankments, and also by canals and roads. Flooding is thus often inevitable in this area under existing conditions. The erection of flood-retarding reservoirs in the catchment area, improving existing channels, and removal of obstructions to drainage in the delta require planning on a large scale. It is desirable that detailed hydrological studies and small-scale model experiments should be undertaken for this purpose. Flood forecasts, construction of emergency refuge mounds, and other ameliorative measures can be undertaken in the meantime.

## XXV. COLLOIDS IN BIOLOGY, MEDICINE, AND AGRICULTURE.

*(Sections of Chemistry, Zoology, Medical Research, Physiology, and Agriculture, in co-operation with the Society of Biological Chemists, India.)*

PROF. S. S. BHATNAGAR presided.

1. PROF. J. N. MUKHERJEE, Calcutta, opened the discussion.

The subject-matter of the present discussion is very comprehensive, and in order to avoid being diffuse I shall restrict myself to those aspects of the properties of colloidal systems, which serve as a connecting theme regarding their rôle in biology, in medicine and in agriculture. Even then I shall restrict myself only to some fundamental considerations of the subject. It would, however, be helpful briefly to discuss what we under-

stand by colloidal systems. Historically, the distinctive properties of colloids rest, according to Graham, on their slow diffusion, their inability to pass through parchment and similar membranes and the difficulties of obtaining them in a crystalline form. These characteristics, which were thought to distinguish colloids from the 'true' solutions of crystalline substances, were later found to be inadequate to classify substances into mutually exclusive 'worlds of matter', namely, crystalloids and colloids. For crystalloids were obtained in a colloidal condition and *vice versa*, and we began to speak of the colloidal state of matter. This, however, is again a vague term, and the vagueness is best illustrated by the so-called physical and chemical theories contending sway in the treatment of colloidal systems. In fact references to these theories have become so commonplace that their contents are often taken for granted and it is seldom that questions were asked till recently as to what they really connote. Even at the present time opinion is far from being unanimous. I have discussed this question in several publications, and I shall briefly refer to some criteria, which will serve to bring out the characteristic properties of colloidal solutions and systems and to reconcile, to some extent, though not completely, the postulates of these two theories. It will also serve the purpose of inviting discussion on these central themes in the theoretical treatment of colloidal systems.

Differences of optical heterogeneity, though useful as a rough guide, do not serve as satisfactory criteria. For they depend on the wave length of light used and the size, shape, and the arrangement of the particles. They do not bring out the differences of systems, in which the thermodynamic equilibrium can be treated unequivocally in terms of well defined components and phases, with those in which their properties cannot be so treated. The question arises how far colloidal particles can be treated as molecules.

It is true that the kinetic theory affords a satisfactory definition of molecules in terms of the translational energy of the different particles, either in the liquid, solid or gaseous state. Let us call a particle, which answers this criterion, a *physical molecule*. In cases where the kinetic theory falls short the quantum theory, in its simpler formulations, still enables us to distinguish these physical molecules on the basis of the probability of the distribution of their translational energy. But this criterion is too comprehensive and it is often not possible to distinguish a colloidal particle from true molecules. Where colloidal particles show Brownian movements they surely behave as physical molecules in the above sense.

Fortunately the definition of *a chemical individual*, in terms of Gibbs' criteria of a *component* in chemical systems in thermodynamic equilibrium, serves as the most helpful criterion. Let us then call the components in all such systems as *chemical molecules*. The terms heterogeneity and homogeneity now assume a different but unequivocal significance. Following Gibbs we see that in all systems, ordinarily met with in chemical equilibria, the magnitudes of the internal energy, of the entropy, of the free energy, of the thermodynamic potential, are single valued functions of the number and concentrations of the different components present in the system, and the two external variables, pressure and temperature. Now in ordinary chemical equilibria the interface, interfacial energy and the individuality of the different portions of any homogeneous phase which are present in the system are neglected. But when the degree of dispersion is great the magnitude of the interfacial energy makes its effect felt. We may therefore usefully define colloidal systems as those systems whose behaviour show definite departure from that predicted by classical chemical thermodynamics, in the sense that considerations of interfacial energy and of the conditions existing at the interface are necessary for the elucidation of their behaviour. Though this definition does not encompass all types of colloidal behaviour, it helps us to find a more comprehensive definition and we may define colloidal behaviour generally as those properties which owe their origin to the presence of an interface, to the

mutual arrangement and association of individual portions of homogeneous phases and the shape and size of the individual portions. In consequence, colloidal behaviour, met with in different branches of science, admits of a great measure of co-ordination.

*Electrification at interfaces and interaction of colloidal systems with electrolytes.*

One of the properties of interfaces, which differentiate them from a homogeneous phase, is illustrated by the conditions of electrification which are often met with in interfaces. Inside a homogeneous phase the following conditions are invariably held to be satisfied; a constant chemical composition, a constant chemical potential and electroneutrality. By this statement we understand that across any plane, covering a sufficiently large number of molecules, both the chemical potential and chemical composition have constant values and the net electrical charge is zero, independent of the location of the plane. In interfaces, however, either as a result of orientation of molecules and their polar character, or of the distribution of electrified particles, usually electrolytic ions, planes parallel to the interface may show a variation in the chemical composition, the electric potential, and the net electrification. In consequence, surface pressure, surface orientation, surface potential, and the potential of the electrical double layer assume considerable importance in the study of colloids.

Let us consider two colloidal systems of widespread interest namely, proteins and the inorganic colloids present in soil. The types of interaction between proteins and electrolytes are many and diverse. The first attempts, following the lead given by Duclaux, Michaelis Pauli and McBain, which aimed at the systematization of the vast experimental material, were based on an application of the concepts of classical electrochemistry to these systems. Proteins are treated as ampholytic systems with definite acidic and basic dissociation constants. And we are familiar with the nomenclature of Michaelis namely, the designation of colloidal systems having electrolytic properties as 'acidoid', 'basoid' and 'saloid' systems. The concepts of classical electrochemistry are assumed to be applicable, but there is also an implied recognition that certain peculiarities arise out of the large size of the protein molecule or ion. These theoretical treatments often suffer from a good deal of vagueness, which masks the important question whether these classical concepts are capable of *ad hoc* application, that is, whether there are not definite facts which contradict some unambiguous deductions from them. The investigations of McBain on soaps, which led to the formulation of the expression 'colloidal electrolytes' and a definite idea regarding the peculiarities of the electrolytic conductivities of micelle ions', established some characteristic differences of these systems from ordinary electrolytes. But they were considered to be only a peculiar class of electrolytes, amenable to the usual theoretical treatment. Indeed, McBain has denied the usefulness of the concept of an electrical double layer which he calls 'the fictitious electrical double layer'. Certain calculations and theoretical considerations by the speaker, however, show great discrepancies in the conductivity of such colloidal systems from that deduced from the basic theories of electrochemistry in their present forms. Recent experimental investigations in several laboratories have focussed attention on these differences. The dissociation constants, degrees of dissociation, total acidities, activity and conductivity coefficients have no such unequivocal meaning as in the case of usual electrolytic systems. Such investigations have mostly been carried out, in this laboratory, with inorganic colloidal systems such as aluminium hydroxide, silicic acid, hydrogen clay (which is more complex) and also with comparatively simple organic substances such as straight chain sulphonic acids, e.g., Undecyl-Lauryl-, and Myristyl-sulphonic

acids by McBain and Betz and cetyl-pyridinium and cetyl-trimethyl ammonium bromides by Hartley. McBain concludes that micelle ions cannot be regarded as mere polyvalent electrolytic ions.

Recent work in the speaker's laboratory illustrate not only the usefulness but also the necessity of the concept of the electrical double layer, a point of view, which has been emphasized by Wiegner and his co-workers in their researches on clay systems. It is very difficult and at the same time obviously necessary to obtain unambiguous evidence that the deductions from classical concepts are contradicted. Interactions of silicic acid, aluminium hydroxide and hydrogen clays with electrolytes appear to afford such evidence. Most of these colloidal solutions should be treated as polyphase systems, but it is difficult to define the phases. It also appears reasonable to conclude that often the equilibrium is between the double layer and the ions in true solutions. Considerations of the adsorption of ions, which are so important in a number of colloidal phenomena, are helpful. Ion-pairs formed on the surface of the colloidal particles seem to govern the equilibria. An interesting instance of the formation of such ion-pairs is afforded by the works of Ghosh and of Chlopin and Balandin on precipitated manganese dioxide.

Compared to the inorganic substances, referred to above, the protein systems offer points of difference; the former are known to be insoluble and their colloidal solutions should be regarded as polyphasic. It is, however, difficult to ascertain the solubility of proteins. There is, however, the important researches of Sorensen, which show that some proteins, prepared with great care, show a definite solubility. It is, however, necessary to point out that a reproducible constant composition of the solution in contact with the solid material of the protein at a single temperature, does not necessarily imply a constant solubility; for constancy of composition of a substance and of the liquid phase in its contact, is not, in itself, a sufficient criterion of its chemical individuality. It is necessary to show that the observed solubility, or rather the constant activity of the protein at a given temperature, would explain a sufficient number of chemical equilibria in which the substance takes part, just as the run of a curve cannot be depicted by a single point. If, for example, in addition to a constant solubility, the heat of formation of the saturated solution and the relevant specific heats are known, so that a temperature solubility curve satisfying thermodynamic criteria can be constructed, the identification of a given protein as a pure substance, i.e. a single component or a chemical individual, could be established. Unfortunately proteins are very susceptible to changes, even in contact with simple electrolytes and time also acts as a factor. Besides on account of the large value of their molecular weight, a small concentration of other components, from which it is often difficult to separate them, may considerably affect the molecular composition of the system. The increasing number of well-crystallized substances of high molecular weight, however, may be taken to indicate that it is difficult *a priori* to set a limit to the size of a chemical molecule. From the above it would appear that though protein systems show many instances of typical colloidal behaviour they lie on a border land.

*The colloidal dimension.*

Protein systems offer an instance of the difficulty of differentiating colloidal from molecular systems on the basis of the size of the ultimate particles taking part in chemical reactions. Colloidal solutions of gold may have very small particles, whose size is very much less than that of many truly dissolved molecules. The process of formation of a saturated solution represents a spontaneous splitting of the mass into ultimate particles, the size and number of which are completely defined. Conditions are different in colloidal solutions. Attempts have been made (e.g. Donnan, Tolman) to build up a thermodynamic treatment of systems of

colloidal particles, based on the similarities and by including surface energy amongst the variables which are taken to determine the total energy in chemical thermodynamics. We know that oil disperses in water in the presence of suitable emulsifiers. It appears to simulate the process of solution. The size distribution curve, however, depends on the emulsifier and the condition of the emulsification. But in most cases the emulsions can be shown to constitute a heterogeneous system. If we take the simple systems of a number of droplets of a pure substance. enclosed in a given space, they can only be in stable equilibrium so long as they do not come in contact and if the vapour pressure of each particle be the same. The curvature and hence the size and the shape must be identical If, however, some of the particles are electrified and some are not, particles of different size and shape may be in equilibrium. Similarly, if instead of a pure substance we take drops of a solution, particles of different size and shape may also be in equilibrium. Besides, the interface is the seat of chemical interactions which lead to a displacement of equilibrium, formation of molecules not equally stable in the contiguous homogeneous phases, and the orientation of molecules. They also affect the kinetics of chemical reactions. These considerations illustrate that the interactions of various sources of energy at the interface may lead to a stable equilibrium between particles of different size and shape, even though the system as a whole is not homogeneous, as ordinarily understood. But in contrast to ordinary chemical equilibria, the conditions obtaining in these systems do not seem to lead to a permanent adjustment between the different sources of energy. In fact, this want of permanent adjustment seems to mark the fundamental characteristics of colloidal systems, specially the biocolloids which are in addition very susceptible to chemical changes. To this feature may be ascribed their importance and association with bioprocesses and biological systems. They admit of more continuous changes which are brought about by small changes in the absolute value of energy. It is therefore not so much the size of the particle but the nature of interfacial energy and the ease with which the association between the individual particles on the one hand and that between the particles and the 'dispersion means' on the other, which characterize colloidal systems and their importance in such widely different branches of science as meteorology, geology, soil science and biology. The size is of importance only in so far as the size determines whether interfacial energy has attained a magnitude comparable with the contribution of the other factors to the total energy. In purely physical processes, such as Brownian movement, rate of settling, the scattering of light and others, the dimension of the particle has of course its importance.

*Solvation and structure.*

The relation between the particles and the 'dispersion means' is illustrated in agriculture by the speculations regarding the manner in which the moisture is associated with the soil and in protein systems by their hydration. The mutual relationship between particles is well illustrated by the stream double refraction of certain colloidal solutions. We have to consider in addition to the 'isotropy' and 'anisotropy' of the substance in bulk, of which the particles are composed, the 'isometry' and 'anisometry' of the particles. The elastic properties of gels illustrate the importance arising out of the structural arrangement of the particles. The interplay of solvation, structure, the electrical double layer and surface tension give rise to such characteristic colloidal properties as coagulation, syneresis, shrinkage, swelling, solation, gelation, thixotropy, antagonism, dilatancy, plasticity, etc.

A similar difficulty regarding the differentiation between the colloidal and crystalloidal systems arises when one considers solvation and structure. Solvation and formation of hydrates, solation and solution, gelation and

salting out, crystal structure and gel structure are pairs of phenomena which show some similarities between themselves. The imbibition of moisture by gels which often lead to swelling shows considerable similarity to the absorption of moisture by some crystalline substances, e.g. chabasite. In quite a large number of cases the criteria set forth above help us to differentiate between these parallel types of behaviour. But when we come to the border land, represented mostly by biocolloids, the differentiation loses its sharpness. Ultimately a general theoretical treatment will be available, which will reconcile these differences and fully account for the similarities. The possibilities of such a reconciliation in the case of the simpler inorganic colloids, in so far as their interactions with electrolytes are concerned, have been indicated by the speaker in a recent publication.

3. DR. A. N. PURI briefly referred to some special problems of Soil Chemistry.

There was a short discussion in which Prof. S. S. Bhatnagar and Prof. V. Subrahmanyan joined among others.

## XXVI. RELATION OF ZOOLOGY TO MEDICINE, VETERINARY SCIENCE AND AGRICULTURE.

*(Sections of Zoology, Medical Research, Veterinary Research, Entomology, and Agriculture.)*

A joint meeting of the sections of Zoology, Entomology, Medical Research, Veterinary Research and Agriculture was held in the Auditorium of the All-India Institute of Hygiene on January 5, 1938, at 1-30 P.M. Col. R. B. S. Sewell was in the chair. The meeting was largely attended and a number of Oversea delegates participated in the discussion.

1. DR. BAINI PRASHAD, Calcutta, opened the discussion.

Detailed biological and ecological studies carried out all over the world have clearly shown the great dependance of the various types of plant and animal life on one another, and the very great influence exerted by some of them on the different types of food-crops, fruit-trees, animals, etc., which are so essential for the existence of human life. The great advances made within the last half a century or so in the study of diseases and parasitology have further shown the very great importance of the various classes of animal parasites, particularly protozoans and helminths, in connection with health problems, not only of mankind but also of the various classes of domestic animals. In connection with the latter, the importance of Animal Husbandry, particularly in reference to their breeding, selection and genetics, has opened up very wide fields of research.

In opening the discussion on the relation of Zoology to Medicine, Veterinary Science, and Agriculture the author discussed briefly the interrelationships of these subjects along the lines indicated above. In regard to Veterinary Science and Agriculture, the question of biological control was referred to and its importance stressed in connection with any measures that might be suggested or adopted for the control of various animal pests and parasites.

2. Dr. Dev Raj Mehta, Kasauli.

*Possible Rôle of Arthropods as Vectors of Typhus.*

In the Simla Hills there exist two types of typhus fever, the serum of one agglutinating strain of *Proteus* × K and not × 19, whilst that of the other gives the opposite reaction. Cases of typhus × K are reported during August and September and those of the × 19 type occur during mid-winter and early spring. Probably this seasonal incidence of the two types of typhus is dependent on the prevalence of different arthropod vectors on the possible rodent reservoirs of infection at these particular periods.

A total of 2,451 rats, mice, and shrews were trapped at Kasauli and Sabathu during 1935-36. The rats are the accepted reservoirs of typhus in other countries and harbour a virus identical to that obtained from human sources.

Amongst the external parasites on these rodents are included the fleas —*Xenopsylla cheopis*, *Ceratophyllus simla*, *Ctenocephalus canis* and *C. felis*, and *Leptopsylla segnis*. The principal mites observed are *Liponyssus bacoti*, *Dermanyssus* sp., *Echinolaelaps echidninus*, and larval forms of *Trombicula*. The ticks are represented by the immature stages of *Hyalomma aegyptium*, *Rhipicephalus sanguineus* and *R. haemaphysaloides*, *Haemaphysalis* sp., and adults of the genus *Ixodes*. The louse *Polyplax spinulosa* is very frequently found.

The fleas (*X. cheopis* and *C. simla*) are the likely vectors of the × 19 form of typhus. The possible rôle of rodent ectoparasites as vectors of typhus × K will be discussed.

3. Dr. A. C. Aggarwala, Lahore.

*Zoology in relation to Veterinary Science.*

In this general paper, the author, after defining Veterinary Science in terms of animal husbandry, has stressed upon the maintenance of animal health and efficiency, including protection from the ravages of disease as an all-important factor in the success of agricultural life and procedure in India. Without a true knowledge of the cause of disease, remedial measures cannot be appropriately determined and effectively applied. The elucidation of the cause of disease, however, is not altogether a one-man issue. There are so many sides of a disease that the definition of causation invariably requires the collective effort and opinion of experts in special sciences before any tangible summing up can be arrived at. A suitable team of research workers, including physicists, chemists, biochemists, botanists, zoologists, veterinarians, etc., must all collaborate and render necessary aid in the survey of circumstances which point to the different aspects of animal diseases. A zoologist is particularly indispensable in the field of Veterinary Parasitology which includes Veterinary Protozoology, Helminthology, and Entomology. Even till to-day comparatively little is known about a number of parasites which set up a variety of diseased conditions in domestic animals and are responsible for heavy losses to the country. Apart from this, a working knowledge of zoology is essential not only to qualify as a veterinarian but also for the everyday duties of a qualified veterinary surgeon. Again, in animal breeding, which has been very aptly defined by Dr. Crew as 'an adventurous experimental study in applied biology', a knowledge of the principles of evolutionary biology and an up-to-date study of the research work carried out by the zoologists in the field is extremely useful. The author, however, does not appear to be very much struck by the ultra-academic sentiment that 'polite learning and true culture admit no contact with utility', and from a practical standpoint and as a veterinary field worker, he points out that while tackling Veterinary Parasitology one

should not become so much engrossed with the parasite as to forget the disease.

4. Dr. M. Sharif, Aligarh.

*On the Relation of Zoology to Medicine and Veterinary Science, with reference to Fleas and Ticks.*

Fleas and ticks are external parasites of great economic importance. They transmit numerous diseases to man and domesticated animals and are also harmful in other ways. They have thus a direct bearing on medicine and veterinary science and an indirect bearing on agriculture.

(A) *Fleas.*

Fleas affect man and domestic animals in two ways: Firstly as vectors of diseases and secondly as blood suckers and annoyers of man and domestic animals.

The chief interest of fleas centres round their connection with the bubonic plague which is primarily a disease of rodents from which it is transmitted to man by fleas. This disease has played havoc with man from times immemorial and is caused largely, if not exclusively, through the agency of fleas. In India alone upwards of 7,000,000 deaths, due to this disease, occurred between the years 1896 and 1911.

A disease known as infantile Kala-azar, found in countries bordering the Mediterranean Sea, is also supposed to be transmitted by dog or human flea. Fleas are the suspected vector of Kala-azar, though competent opinion is still divided. *Xenopsylla cheopis* can transmit the causative agent of Tsutsugamushi fever under experimental conditions. Haemorrhagic septicaemia, a fatal disease due to *Pasteurella boviseptica*, in cattle is transmitted by *Ctenocephalides felis*. Fleas can also transmit Rickettsial diseases in man. A flea acts as the intermediate host of the tapeworm belonging to the species *Dipylidium caninum* which is found in dog and occasionally in man.

Besides the transmission of diseases, fleas are troublesome parasites. In many cases they are said to have rendered houses or other places uninhabitable for a time. The Sticktight flea (*Echidnophaga gallinacea*) is responsible in the tropics and certain parts of the United States of America for a considerable annual loss to poultry breeders. The Chigoe (*Tunga penetrans*) causes painful sores in man or even crippling if neglected. During the Great War in East Africa the British Army had to wait for two days to occupy a position of great advantage vacated by the Germans, on account of its being infested with fleas of this species.

Fleas afford us a good instance that a mere systematic study of a group sometimes helps to clear up certain points of great economic importance. The Plague Commission in India failed to understand the reason why certain places having similar ecological conditions had severe plague while others like Madras and Colombo were comparatively immune from it. It was found by Rothschild and Hirst that in the plague-free places the rats were infested with *Xenopsylla astia* which is an inefficient vector of plague bacilli, and in areas infected with plague, *X. cheopis*, which is the most efficient vector of plague bacilli, predominated. Thus a much despised systematic study of this group helped in explaining a puzzle which the trained applied entomologists with enormous funds at their disposal could not explain in a period of seven years.

The ecological work done on fleas by Buxton, Leeson, Sikes, Bacot, and the present author deserves to be mentioned. If the applied workers in this field take advantage of their pioneer work, they will be able to understand the flea problem and thus save humanity from its depradation.

(B) *Ticks.*

The harmful effects caused by ticks to animals and man may be due to (*a*) their bites, (*b*) extraction of blood, (*c*) transmission of diseases, and (*d*) tick toxæmia.

(*a*) *Tick bites.*—It is a well-known fact that the bite of a tick causes ulcers or small wounds which may serve as suitable places for bacterial infections. If the wound caused by a tick bite is large, the eggs may be laid by flies which develop into maggots and cause cutaneous myiasis. Ticks occurring on legs and between digits in sheep and cattle give rise to sores resulting in lameness. The fowls may die of 'tick worry'.

(*b*) *The extraction of blood* by a large number of ticks makes the cattle so weak that they are depreciated in value from the commercial point of view. It makes them unfit for work and in milking animals the yield of milk is reduced to a considerable extent. Repeated attacks by large numbers of ticks shorten the life of animals and make them weak so that they become an easy prey to other diseases.

(*c*) *Transmission of diseases.*—The importance of ticks in general as transmitting agents of various diseases of man and domesticated animals continues to become more manifest as our knowledge of them increases. Smith and Kilborne (1893) made the first remarkable discovery of the possibility of transmission of protozoal parasites by arthropod hosts by demonstrating the transmission of *Babesia bigemina* by *Boophilus annulatus*. This discovery by Smith and Kilborne opened up the vast field of research on the part played by Arthropods in the transmission of protozoal diseases, which has since then revolutionized our knowledge of tropical diseases. In man ticks transmit the causative agents of the relapsing fever (Spirochætosis) all over the world, the Rickettsial diseases like Tick typhus, Marseilles fever and the Rocky Mountain spotted fever of America and Tularaemia. In domestic animals they transmit diseases caused by *Babesia*, *Theileria*, *Anaplasma*, *Bacteria*, and Viruses.

(*d*) *Tick toxæmia.*—According to some observers the salivary secretion of ticks contains toxins, and cases of tick paralysis in some animals and man are generally explained on the basis of their presence. According to Regendanz and Reichenow (1931) the poison causing tick paralysis is specially formed in the female of *Rhipicephalus sanguineus* during the process of egg development. They experimentally showed that injections of eggs or ovaries of this tick just before oviposition gave rise in dogs to symptoms similar to those of tick paralysis.

The ecological studies on ticks have yielded useful results for their control. Unfavourable climatic conditions which are mainly responsible for keeping the number of ticks in check, have been studied in some countries. Ticks have natural enemies both predaceous and parasitic. The study of their effects in limiting the increase of the population is being made at present in some countries. Regarding the parasitic enemies of ticks a serious attempt by highly trained persons is being made at present at Montanna, where a research laboratory costing about sixty thousand dollars was specially built for this purpose in 1927. According to Cooley for the time being the use of tick parasites appears to afford the most promising method of control.

5. MR. M. AFZAL HUSAIN, Lyallpur.

*Relation of Zoology to Agriculture.*

Agriculture has always been, and will continue to be, the fundamental industry of India. Zoology is intimately connected with this industry. In Indian farming animals play directly a very important part. The cow is indispensable, not simply because it provides wholesome food for human beings, but also because it provides the most essential draught animal—the bullock. The earth resting on the horn of a bullock is a

true representation of the importance of this animal in our agriculture. Besides, cattle are important to Indian agriculture as producers of manure which is so necessary for maintaining soil fertility. Again, cattle breeding, sheep breeding, poultry rearing, apiculture, lac culture, and seri-culture are well-recognized subsidiary industries for a farming community.

Further, animals of various groups directly and indirectly interfere with efficient Agriculture by destroying crops and domestic animals. Protozoa, worms, insects, birds, and mammals include serious foes of the cultivator. Perhaps insects, sparrows, and rats cause damage to our agriculture which is many times more than the cost of armaments, even at the present time of feverish activity in re-arming.

A science, the object of which is the study of animals, has a direct bearing on our agricultural prosperity. Knowledge of our animal friends and foes will enable us to harness and control these tremendous zoological forces to our best purpose in order that peace and plenty may prevail in this world.

6. Prof. F. A. E. Crew, Edinburgh.

*The influence of heredity on resistance to disease.*

The problem of resistance to disease is of great scientific interest and also of vital practical and economic importance. It is a complex problem demanding for its attempted solution the aid of the bacteriologist, the protozoologist, the physiologist and the geneticist together with others.

The degree of resistance, ranging from immunity to extreme susceptibility, depends upon a multiplicity of factors which may be grouped under the headings: environment, function, and inheritance.

The evidence in favour of inherited predisposition to or relative immunity from disease is overwhelming, but the relative importance of heredity, function, and environment still remains an unsolved problem.

[The author could not attend this meeting.]

7. Dr. B. Sundara Raj, Madras.

*Fisheries—the Problem of Food Supply in India.*

The health of a nation is its greatest asset and the foundation of all health is a sufficient and properly balanced diet. It is now being emphasized on every hand that the diet of the average villager is neither sufficient nor balanced, and scientific data is becoming increasingly available to prove exactly where and how the diet of the masses is deficient.[1] The field enquiries so far made of groups of families show that according to the standard accepted for the average requirements of a manual worker in the Tropics, even villagers who are a little better off than the poorest classes of cultivators are underfed,[2] and most of the latter have accustomed themselves to a state of semi-starvation.

Even worse from the physiological point of view than the insufficient diet of the masses is the lack of essential food factors in the food that is taken. These are protein, fat, and Vitamin A. Such protein as is obtainable at present by the villagers is usually vegetable protein of poor biological value.[3] The Expert Commission of the League of Nations on Nutrition has reported that 'during growth, pregnancy and lactation,

[1] Press Communique—Director of Public Information, dated 5-4-1937.

[2] Ceylon Journal of Science, Vol. IV, Part 1, dated 21-4-1936, and Dr. Aykroyd and Mr. B. G. Krishnan 'Diet Surveys in S. Indian Villages'; Indian Journal of Medical Research, Vol. XXIV, No. III, January 1937, pp. 671–673.

[3] *Ibid.*, p. 679.

some animal protein is essential and in the growing period it should form a large proportion of the total protein'. Dr. Aykroyd has found that in devising cheap balanced diets in India, the inclusion of animal protein in adequate amounts is the point which presents the greatest difficulty.[1]

The sources of animal protein are milk, eggs, meat and fish. Milk is the most valuable food known, yet it has been calculated that for the Madras Presidency only 3·6 oz. per head per day is available from cows, buffaloes and goats combined.[2] In point of fact the great majority of poor families consume no milk products at all.

*Meat.*—India has more than a quarter of the cattle of the whole world—in fact they have been calculated to number 2 for every three of the population—yet their milk yield as we have seen is negligible and their flesh is forbidden as an article of food to Hindus. Beef and pork therefore are used by only small sections of the population. There remains mutton from sheep and goats -poultry is negligible—of which the available supply has been calculated for the meat eating population of the Madras Presidency at hardly ·6 grammes of protein daily.

*Fish.*—The prime source of fish is the sea, but apart from a negligible amount sent inland in ice for a few well-to-do customers the consumption of fresh sea-fish is confined to a narrow belt of country 10-15 miles wide along the Coast which can be reached by runners, and possibly 50-60 miles from the Coast where bus traffic exists. But in the inland areas, where animal protein from other sources is in such serious defect, fresh fish, except what can occasionally be obtained from tanks and rivers, is altogether unprocurable. Cured fish, of which a limited amount is available, loses some of its most valuable qualities during the process of curing, especially by the methods usually practised in India.

The statistics of consumption for a coastal town are available [3] and make interesting reading. Madras City, which had in 1922 a population of 527,000, was found as the result of a daily market enquiry to consume about 9¼ lbs. of fresh fish per head per annum, taking only 80% of the population as fish-eaters. This means that in a city actually situated on the Coast and containing a large proportion of people living in European style, many of whom take fish daily, and also a much greater number of people whose standard of living is certainly above that of the average villager, the average daily consumption of fish per head is only ½ oz. It can therefore be safely assumed that as a source of protein to the underfed masses in the great inland areas fish is practically unknown.[4] So much for protein. The next serious deficit in Indian diet is its low fat content and in consequence the virtual absence of Vitamin A. According to Dr. Aykroyd the daily amount of fat necessary is 1½ to 2 oz. or 40 to 60 g.[5] The survey showed an average of only 4·4 g. daily for poor families and 26·9 g. if well-to-do ones were included.[6] Fat in itself is a necessary article of diet, while the absence or deficiency of fat-soluble Vitamin A is the source of much of the general low standard of vitality found every where as well as the prime cause of widely prevalent diseases such as Keratomalacia, Kerophthalmia and certain skin diseases. No Indian

[1] Health Bulletin No. 23, The Nutritional Value of Indian Foods and the Planning of satisfactory diets by Dr. Aykroyd, 1937.

[2] Imperial Council of Agricultural Research Report 'Review of the position of dairying and the development of Dairy Industries in India', 1936.

[3] Madras Fisheries Bulletin, Vol. XV, No. 6. A statistical account of the Fish Supply of Madras. S. T. Moses. 1922.

[4] Indian Journal of Medical Research, Vol. XXIV, No. 3, p. 679 and Vol. XXV, p. 5, 1937.

[5] Health Bulletin No. XXIII, 1937, p. 5.

[6] Indian Journal of Medical Research, Vol. XXIV, No. 3, pp. 671-672, 1937.

vegetable oil contains Vitamin A but animal fats such as butter and ghee, and particularly fish liver oils are rich in Vitamin A. As we have seen, these are precisely the elements in the food supply that are so lamentably defective over the greater part of the population, especially of inland areas.

The population of India is rapidly growing. The birth rate is computed to be double the death rate and in another 3 years the total population is likely to reach 400 millions. The only important food industry in the country is agriculture, but the total area under food crop only amounts to ·72 acre per head,[1] and the production of food from this, even with improved methods and materials, cannot quickly or completely make up the serious discrepancy between population and food supply. The importation of food is precluded by the poverty of the masses.

We are therefore driven to the conclusion that some new source of food supply must be found, and that this supply must be particularly rich in protein, fat and Vitamin A. In Indian fisheries we have a source of food supply capable of immediate and immense expansion, and what is of the greatest importance, able to supply cheaply and abundantly just those factors that are so seriously lacking in the unbalanced diet of the masses of the people. At least 80% of the population will eat fish.[2] There seems to be no objection from any section of the community to fish oil as medicine. The Indian coast line gives us some 4,800 miles of access to wide seas practically unfished. At present regular fishing is only carried on by primitive methods over the greater part of the coast line, but fairly accurate statistics are available of fish landed on the Malabar Coast of the Madras Presidency. The average catch per sq. mile works out at 98·8 tons,[3] and on this basis the possible production of the sea up to the 100 fathom line, which trawling experiments have shown to be the most productive,[4] should amount to 120,000,000 tons. When fully exploited, therefore, the sea fisheries of India, excluding Burma, should be able to provide 37½ g. of protein per head daily. This will more than make good the deficiency of 29·9 g. of protein in the diet of the poorest classes as recorded by Dr. Aykroyd, and it will be protein of the greatest biological value. The fat content of the diet will also be considerably augmented if the amount of 131¼ lbs. of fish annually per head of the population becomes available by proper exploitation, conservation and distribution of the harvest of the sea.

The deficiency of Vitamin A which in the average diet is responsible for so much suffering and economic loss among the villagers, will at once be made good by the addition of fish or fish oil to the food. Cod liver oil has long been recognized as a valuable source of this essential food factor, but the oil of the Indian skate has been found to be just as potent in value; the richest known source of Vitamin A is halibut liver oil, but in spite of crude methods of preparation, it has been proved that Indian shark liver oil has nearly half the Vitamin A potency of halibut liver oil.[5] That is to say, in Indian shark oil we have a potency of Vitamin A equal

[1] Annual Report of the Public Health Commissioner for India for 1933.

[2] The Census Report of 1931.

[3] Madras Fisheries Bulletin: Fish Statistics from 1925-26 to 1930-31.

[4] Collection of papers dealing with the Fisheries Survey of the Bay of Bengal—Calcutta, 1911;

Report on the work of the S.T. 'William Carrick', Department of Industries, Bombay, 1923; and

A Preliminary Report on the possibilities of Commercial Trawling in the Sea around Ceylon—Ceylon Journal of Science, Section C—Fisheries, Vol. II, 1926, pp. 1-166.

[5] Annual Administration Reports of the Madras Fisheries Department—1935-36, Paras 79 and 80; 1936-37, Para 92.

to ten times of cod liver oil. Even Malabar sardine oil, which could easily be made both abundant and cheap, has been found where properly prepared to contain a quarter the Vitamin value of the best imported cod liver oil.

In his Presidential address to the Agricultural Section last year Mr. Viswanath estimated the total output of food nitrogen from all classes of crops in India at only ⅔rds of the actual requirements of the population.[1] Indian fisheries potentially offers an enormous and hardly exploited source of food supply which concerns the bulk of the population and which if developed will go far to revolutionize the diet of the masses besides conferring on the people other attendant benefits of increased wealth and occupation and may form a training ground for the future Indian Navy and Mercantile Marine.

8. PROF. W. M. TATTERSALL, Cardiff.

The development of the commercial fisheries of India as a source of food supply, so ably advocated by Dr. Sundara Raj, is to be whole-heartedly commended. If, however, it is to be successfully accomplished it should be done on strictly scientific lines from the commencement. The great need of India to-day is the establishment of a fishery department for all India, such a carefully planned programme of Scientific research into fishery problems, covering a long period of years designed to co-ordinate and develop the commercial fisheries of the whole country. The marked success which has attended scientific research into fishery problem in Europe during the last thirty years deserves careful study by those who are interested in the development of Indian fisheries. Such success had as a basic, purely scientific zoological studies on the plankton and on the scales of fishes, but these studies had been found to be of enormous value when applied to fishery problems, for instance, as a result of such work it is now possible to forecast, not only the yield of the herring fishery in any particular season, but also to indicate the areas which can be fished most profitably. This forecasting of the herring fishery had enabled the industry to plan its work on economic lines with a definite saving of time, labour and money. The precise methods of research, so successful in Europe, may not be strictly applicable to Indian conditions and problems, but the lessons of carefully planned research and its results should be carefully studied and taken to heart. It should not be difficult to modify and adapt European methods to the distinctive problems of India. If the fisheries of India are exploited solely from the commercial aspect, without regard to the scientific principles which should be their fundamental basis, there would be grave danger of the fisheries being ruined in the end. The problems of overfishing and close seasons especially require to be borne in mind and the lessons to be learned from earlier disregard of these aspects of the fisheries in Europe carefully noted.

9. COL. A. OLVER, Mukteswar.

I have prepared no paper for this meeting but there are a few remarks I would like to make in regard to what has fallen from previous speakers. I feel that the most important aspect of an Husbandry in India at present is the nutritional aspect as it concerns the human race and I am very much in sympathy with the Director of fisheries who has drawn attention to the importance of fish as a source of first class protein and vitamins in which Indian diet is so lacking.

The development of Fisheries is not a subject with which we of the I.C. of A.R. are directly concerned except as regards inland fisheries but realizing that something ought to be done we have endeavoured as far as

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[1] Proceedings of the Indian Science Congress, 1937, p. 354.

possible to foster the development of sea fisheries which you have heard could furnish an immense supply of most valuable food.

Then there were a few points regarding the supply of milk to which he would like to refer. It had been said that in Madras the consumption of dairy products of all kinds per head per day did not amount to more than about the equivalent of roughly 3 oz. per day, while surveys carried out by the I.C. of A.R., the marketing survey and Major Gen. Megaw had shown that the average for the whole of India amounted to about 7 oz. per diem. This was far too low particularly for a population which is predominantly vegetarian and there was no reason why it should not be greatly increased. It was commonly said that Indian cows were hopelessly bad milk producers but they had been able to prove that this assumption is quite incorrect. Figures which had been obtained by the investigation carried out by the animal Husbandry Bureau of the I.C. of A.R. had shown that if properly fed and managed selected Indian cows could hold their own quite well as milk and butter fat producers. In fact there were now several herds of pure bred Indian milk cattle which even under Indian conditions had reached a higher milk yield than the average of dairy herds in Europe and America. Moreover the average butter fat content of milk of Indian cows was nearly 5% while that of most European breeds was between 3·2% and 3·7%. This investigation had also shown that by proper feeding and management the milk yield of Indian cows could be greatly increased. Ordinarily Indian cows were very badly fed from birth. Only when they were giving milk did they receive anything to supplement what they could pick up and their milk yield was hopelessly low but investigation had shown that the average yield of the same cows under good but not excessive feeding and proper management had all over India been increased by an average of 64%.

Buffaloes had been more carefully bred and fed for milk production and there was not the same scope for further improvement in their case but there was no reason why much better use should not be made of cattle to increase the yield from the land. At present too much attention was paid in India to the production of food crops but if more fodder crops were produced and the cattle better fed on the cultivated lands they could easily increase the yield from crops so that more milk and better cattle would be produced and the return per acre greatly increased.

Looking from the purely zoological point of view he was greatly concerned in the improvement of live stock of all kinds and the main factors in this work were disease control, careful selective breeding, better feeding and to make the most out of live stock it was necessary to make a careful study of existing breeds particularly of cattle. The so-called Indian Cattle were derived from a number of distinct types.

10. Sir Frederick Hobday, London.

I am pleased to be allowed to-day to add my testimony to the value of a meeting like this where the title expresses the importance of working together as a team; and your title is 'the relation of Zoology to Medicine, Veterinary science, Entomology and Agriculture'. Every branch of zoology is of importance to give assistance in the fight against disease and in none more than in the aid it can give to animals—not only in the '*cure*' but (which is of ever more importance) the '*prevention*' of diseases. Agriculture is the backbone of every country and its framework is made up of the produce of its arable land and its animals—in about equal proportions. The wealth of the owner of the animals depends upon the health of the animals—and the health of the animals *must* depend on the man who devotes his life to the study of their diseases and their prevention—i.e., the duly qualified and scientific veterinary surgeon Sir Arthur Olver has spoken of the importance of the study of nutritional diseases to the growth and health of young stock. I wish to emphasize this and to say at this point how very important is the help of the zoologist—whether

he is a specialist in helminthology, Entomology or any other branch of this science. The zoologist studies and works out the life-history and in collaboration with the veterinary practitioner and together they endeavour to discover the place in the life-history of the parasite where the link of the chain can most effectively be snapped.

Your scientists of India have been so hospitable to us that we all hope to be here again at your next jubilee!—and again let me say what great pleasure it has given me personally to be allowed the privileges to spend in this section this afternoon.

11. Prof. G. D. Hale Carpenter, Oxford.

The diseases known as Trypanosomiasis in Africa afford the best example of the interrelation of animals and man. The tse-tse fly disease of S. Africa known to Livingstone and considered by him to be due to some unknown living organism injected into cattle and horses by *Glossina morsitans* was shown by Bruce to be due to a flagellate protozoon, *Trypansome brucei*, derived by the fly from wild animals. When a serious epidemic disease (Sleeping sickness) on the coasts of Lake Victoria in Africa destroyed hundreds of thousands of natives at the end of the 19th century it was shown to be due to an another species of Trypansome. Here the disease and its causal organism were known first: the carrier had to be found. It was shown to be another species of tse-tse fly *Glossina palpalis*, and the analogy with S. African 'Fly disease' of cattle was completed.

12. Principal B. L. Bhatia.

Dr. B. L. Bhatia who started teaching Zoology more than 30 years ago, felt delight in seeing that now there were a number of zoologists who have specialized in Protozoology, Helminthology, and Entomology, and that the Medical and Veterinary Departments were now no longer averse to making use of their services. He further stressed the need of the discoveries of science being made known to the general public, as the general public seem to be under the impression that the cost of scientific research is out of proportion to the benefit that is actually derived by the people. Hence the need for greater publicity and closer co-operation of the public.

## XXVII. A NATIONAL HERBARIUM FOR INDIA.

*(Section of Botany, in co-operation with the Indian Botanical Society.)*

After a few introductory remarks, Prof. B. Sahni requested Prof. S. P. Agharkar to open the discussion.

1. Prof. S. P. Agharkar, Calcutta.

*Opening Remarks.*

By a national herbarium I understand a collection of plants which is fully representative of the species including all their varieties, forms, hybrids, geographical races, etc. found within the country and its adjacent parts and which includes as many types and co-types of these as possible. Each species should be represented from as large a number of localities

and as many types of habitats as possible, so as to afford a complete picture of its distribution and ecology. It should include further all plants cultivated in the country either as food crops for man and beast, raw materials for industry, medicinal drugs, or as ornamental plants. In short, it should include a complete representation of the wild and cultivated plants of the country and their variations.

Such a collection is needed not only for the use of Botanists, but also for Foresters and Agriculturists as well. Its importance for the preparation of local and provincial floras, which are absolutely necessary for the spread of a knowledge of plants among the people and inculcate in them habits of accurate observation is very great. Problems of geographical distribution of plants and their ecology can only be studied with the help of such collections.

The National Herbarium should be associated with a botanical garden (or gardens) for the cultivation of as many species as possible. This will make it possible to study the plants in a living condition, and note the range of their variation.

In order to find out the material that is available in India I wrote to the heads of various Indian herbaria for information regarding the (1) origin and history of their institution, (2) the collections included therein, (3) the staff, (4) library, (5) exploration grant and any other features of interest. From the replies received, it becomes evident that no institution in India can be said to satisfy completely the requirements of a National Herbarium.

The nearest approach to it is the Sibpur Herbarium which could be converted into the national herbarium, if appropriate means are chosen, within a comparatively short space of time and without unduly large expenditure of money. The Sibpur Herbarium contains more than two million sheets and includes a large number of duplicates of some of the earlier Indian Collections.

A detailed account of the collections available in the Sibpur Herbarium is given in T. Thomson's paper 'Notes on the herbarium of the Calcutta Botanic Garden, etc.' published in the Journal of the Asiatic Society of Bengal, Vol. XXV (1856), pp. 405–418. A further account of the Indian collections is given by Sir George King in his address to the Botany section of the British Association at the Dover meeting in 1899 on 'A sketch of the history of Indian Botany'.

The Royal Botanic Gardens, Sibpur, in which the Herbarium is situated, and the Lloyd Botanic Gardens, Darjeeling, afford necessary facilities for the study of living plants.

Another Institution which deserves mention in this connection is the herbarium of the Imperial Research Institute, Dehra Dun. R. N. Parker in Bulletin No. 73 (1931) of the Imperial Forest Research Institute 'The Herbarium of the Forest Research Institute' has given an account of the collections included in the Dehra Dun herbarium. Mr. Parkinson has also contributed a paper on this subject for this discussion. Notices of other Indian herbaria have been given in the papers which have been contributed for this discussion.

Unfortunately very few of the earlier collections, on which the descriptions of Indian plants are based, are now available in India. They are to be found in various British and European herbaria, the most important of which are those of the Royal Botanic Garden, Kew, and the British Museum. An account of the collections at Kew is contained in the paper which has been contributed for this discussion by Sir Arthur Hill. An account of the Indian collections in the British Museum is to be found in Sir G. King's address referred to above. Prof. A. B. Rendle, who has been keeper of the Department of Botany of this institution, and who is with us to-day, will I hope supplement these remarks. Besides these, considerable collections of Indian plants are found in many European herbaria, an account of which is found in de Candolle's Phytographie (1880).

It is useless to speculate regarding the causes which may have led to this result. The fact that nearly all the workers engaged in the Scientific study of Indian plants in those days were Europeans may have had something to do with it. As collaboration with European botanists and comparison with specimens in European Herbaria was necessary for the purpose, most of the collections were taken to Europe for study. A very large part of these, including types of new species have remained in European institutions and only a small part has been returned to India. The absence of any rules, until recently (July, 1937), for the loan, gift or exchange of specimens from the Sibpur Herbarium may have facilitated this.

Distribution of duplicates also was principally confined to European herbaria. The most glaring instance of the omission of Indian herbaria from distribution of Indian plants was the distribution of sets of Wallichian collections, of which no complete set is available in India.

It has thus come about that most of the types of Indian species are found in European herbaria. An unfortunate consequence of this has been that no critical work on Indian plants can be done in India and Indian herbaria have become mainly agencies for the collection of plants for Kew and other non-Indian institutions.

The purpose of this discussion is to suggest ways and means to remedy this situation by the establishment of a National Herbarium and thus make it possible for work on Indian plants being done in India. The absence of types of Indian species from Indian herbaria has already been referred to above. An effort should, therefore, be made to acquire as many types and co-types of these as possible for Sibpur. In cases where it may not be possible to acquire these, specimens should be collected from the original localities—where these can be ascertained—and made into secondary types after matching them with the originals and supplemented by their photographs. In this way a collection will be built up in course of time which will be sufficient for nearly all purposes.

Acquisition of types or co-types is, however, not sufficient by itself to serve the purpose. The institution must also be adequately staffed so that the collections will be properly cared for and made available for scientific investigations.

The present scientific staff of the Sibpur Herbarium consists of the Superintendent and the Curator appointed by the Government of Bengal and one Systematic Assistant appointed by the Government of India. The Superintendent being also the administrative officer for the Royal Botanic Gardens, and Lloyd Botanic Gardens, can only devote a part of his time to this work.

It is obvious that this staff is insufficient if we expect original scientific work from them, and that it is necessary to strengthen it. The least that could be done would be to restore the post of second Systematic Assistant which was retrenched by the Government of India as a measure of economy in 1932. It is further necessary to obtain the co-operation of members of the staff of Indian Universities in working out the collections and in conducting a botanical survey of parts of the country which have not yet been explored. It will be necessary to provide for grants for exploration work both by the herbarium and University staff. It will also be necessary to depute members of the herbarium and university staff to Kew as Liaison officers for periods of 2-3 years each during which they will be able to acquire a knowledge of the collections at Kew and elsewhere.

This can easily be done without extra expenditure if the existing provision for the Assistant for India at Kew is utilized for this purpose.

It is, perhaps, not generally known that India has maintained out of its revenues, the post of an Assistant on the Staff of the Kew Gardens since 1883. This official has, nearly always, been a retired official who has never served in India after the period of his appointment at Kew. The knowledge and experience that he gained at Kew has thus not been

directly available to India. If on the other hand, the assistant for India is chosen from the staff of the Universities as suggested above, we shall soon be able to have a number of Botanists in India with a knowledge of the Indian collections in Europe who could be entrusted to work out Indian collections. The teaching of Systematic Botany in Indian Universities will also markedly improve by this measure.

I made this suggestion at the last Imperial Botanical Conference held in London in 1935. I am glad to say that Sir Arthur Hill, Director of the Kew Gardens, who is with us to-day, has recently proposed to the Secretary of State for India that this method be adopted in future for the appointment of the Assistant for India at Kew. I hope the Government of India will be able to accept this proposal, which is likely to be of immense benefit to India.

Another subject which is likely to be raised in the course of this discussion is a reorganization of the Botanical Survey of India. Prof. Bharucha, of the Royal Institute of Science, Bombay, I understand, wishes to raise this question and press for the constitution of provincial Botanical Surveys.

The present moment may perhaps be regarded as opportune for this discussion as the Director of the Botanical Survey of India has gone on leave preparatory to retirement and no announcement has yet been made regarding his successor. From the arrangements announced so far, it appears that it is proposed to distribute the duties hitherto performed by the Director among three officers, viz. (1) the Superintendent of the Royal Botanic Gardens, (2) Curator of the Industrial section of the Indian Museum, and (3) Superintendent of the Cinchona department, the post of Director of the Botanical Survey itself being kept in abeyance.

The Botanical Survey of India was constituted by the Secretary of State for India in 1885 in order to bring the various provincial Botanical departments into communication with one another. There were four such provincial departments: (1) the Royal Botanical Gardens, Sibpur, (2) the Government Botanist's department, Madras, (3) the Botany Department of the College of Science, Poona and (4) the Botany Department of Northern India at Saharanpur. Three of the provincial departments have now practically ceased to exist.

The Botany Department for Western India, which was attached to the College of Science, Poona, was transferred to the Agricultural College, Poona, on its establishment, and placed in charge of the Economic Botanist to the Bombay Government. One of the assistants of the Economic Botanist looks after the herbarium, there being no arrangement for exploration or upkeep. Purely scientific work is not now being done.

The Madras department has also suffered a similar fate. The post of Government Botanist continues to be kept in abeyance since Mr. Barber, the last holder of the post, was appointed Imperial Sugarcane Specialist. The papers by Mr. Cherian Jacob on the Madras Herbarium and by Dr. F. H. Gravely on the herbarium of the Government museum give an account of these herbaria.

On the abolition of the Northern India Botany Department, its herbarium was transferred to Dehra Dun and on the opening of the new Forest Research Institute in 1909 was amalgamated with the Forest School Herbarium. Mr. Parkinson has contributed an account of this herbarium for this discussion.

Under these conditions it is not surprising that comparatively a small amount of scientific work is being produced by officers of the Botanical Survey.

It is on the other hand gratifying to note that an increasingly larger amount of work is being produced in the Universities, in most of which facilities for research work are available. Some of the Universities have also herbaria attached to their departments, accounts of some of which are found in the communications received for this discussion.

It is, therefore, necessary to associate them more closely with the

work of the Botanical Survey by the provision of exploration grants and facilities for the deputation of members of their staff to Europe for studying the Indian collections available in those countries.

Ladies and gentlemen, I do not wish to detain you further, and request you to express your views on the subject so that a practical scheme can be elaborated for consideration by the proper authorities.

2. Mr. C. C. Calder, Sibpur, Calcutta.

*The Herbarium of the Royal Botanical Gardens, Sibpur.*

The present collections of the Herbarium date from the 18th century. They consist of plants contributed by almost every worker at Botany in India since, and of contributions from Botanists in Europe. It is first and foremost an Indian Herbarium. It contains a fair amount of foreign collections of S.E. Asia, Japan, Persia, Asia Minor, Europe, Africa and America. Invaluable contributions have been received in exchange from the Director of Kew, Sir William Hooker and his son and successor Sir Joseph Hooker. Interchanges with many botanical institutions both in Europe, Asia, India and America have materially enriched the herbarium in the exotic collection. Amongst the private contributors in past times, who have enriched the herbarium collections by their donations, mention must be made of Vicary, Edgeworth, Griffith, Wight, Simons, Law, Gibson, Stocks, Dalzell, Kurz, Miquel, Jenkins, Maingay, Rottler, Heyne and Klein. Amongst contributors in later times may be mentioned Kurz, Scully, Aitchinson, Duthie, Beddome, C. B. Clarke, J. S. Gamble, Brandis, King, Anderson, Falconer, Maclelland, Mann, Fisher, Fischer, Kanjilal (Senior), Collett, Sir J. D. Hooker, J. G. Wood, Rev. J. Campbell, Watt, Burkill, Cave, Pantling, Gammie, W. W. Smith, Craib, Garden collectors and Botanical Survey collectors since 1890.

The superior staff consists of the Superintendent of the Garden and the Curator of the Herbarium.

The Library consists of 22,500 volumes of books and journals arranged systematically under subject and regional heads with alphabetical card index of authors. They are mostly on Taxonomy of plants.

Roxburgh's unpublished drawings running to several volumes and the manuscript catalogue of Wallichian sheets, also unpublished, are features of interest.

3. Mr. C. E. Parkinson, Dehra Dun.

*The Herbarium of the Forest Research Institute, Dehra Dun.*

The herbarium of the Forest Research Institute at Dehra Dun was started by Mr. J. S. Gamble of the Indian Forest Service who became the Director of the Forest School in 1890. To start the collection he presented the herbarium with a duplicate set of his own collections that he made in Bengal and Madras and he added to it by collecting assiduously during his stay in Dehra Dun and from the contributions that he received from various forest officers whom he had doubtless interested in botanical work. Gamble collected exotic plants which are so frequently neglected by collectors and many of these are of interest in that they show the date of introduction and source of many of the bamboos and other plants grown in the Forest Park and grounds of the Forest School at Dehra Dun. Mr. J. F. Duthie of the Botanical Department of Northern India contributed largely to the Forest School herbarium and good local collections of trees and shrubs were obtained by the Instructors and students of the school, especially from Upendranath Kanjilal and Mian Birbal. Several private collections made by forest officers appear to have been presented for instance by A. Smythies from the Central Provinces, Gustav

Mann from Assam, A. Lowrie from Ajmer, J. C. McDonell from Kashmir and R. Ellis from Chamba. By exchange a number of Australian plants were received from Baron von Mueller.

The herbarium was originally housed in one of the buildings belonging to the Forest School, now the Forest Rangers' College in Dehra Dun, and it became part of the Forest Research Institute in the course of its development. In 1908 the herbarium of the Botanical Department of Northern India was transferred from Saharanpur to Dehra Dun and with the opening of the new Forest Research Institute at Chandbagh it was amalgamated with the Forest School herbarium in 1909 and housed with the Forest Botanist's office in a separate building in the Chandbagh estate north of the main Institute building. Nothing is known of the relative sizes of these two herbaria except that the Saharanpur herbarium was larger than that of the Forest School. A note on the origin and development of the Saharanpur herbarium up to the time of its transfer and amalgamation with the Dehra Dun herbarium will be of interest.

The Botanical Gardens at Saharanpur were established in 1816 but no proper herbarium was formed till many years later. Dr. Govan, the first Superintendent, collected plants in the Sirmoor State in the Simla hills and part, or possibly the whole of his collections, which have since not been traced, were listed in Wallich's Catalogue. He was succeeded by Dr. Royle, well known for his 'Illustrations of the Botany of the Himalaya mountains' published between the years 1833 and 1840. Royle, during botanical explorations in the Doon and the hills north of the Doon and the Simla hills, made a collection of herbarium specimens, the bulk of which he took with him on retirement to England and were sold after his death in London for a few shillings, but some that he left behind were preserved in the Saharanpur herbarium. Dr. Falconer succeeded Royle in 1831 and the collections that he made or obtained from various parts of India were mainly sent to London but some have been preserved in the Saharanpur herbarium. Dr. Jameson who succeeded Falconer in 1842 made few collections of interest.

Mr. J. F. Duthie succeeded Dr. Jameson in 1876 as Superintendent of the Botanical Garden and in 1887 he became the Director of the Botanical Department of Northern India and from that year up till his retirement in 1902, was able to devote his time entirely to Botanical work. Prior to his arrival the herbarium occupied a very subordinate position at Saharanpur but he immediately set to work to put what there was of it in order and during his botanical tours he collected extensively and added several thousands of specimens to the herbarium. He also obtained valuable material by interesting civil and military officers in collecting and through the authorities of the Royal Botanic Gardens, Kew, and his two collectors Inayat Khan and Harsukh who toured many parts of India and became efficient and experienced collectors. Duthie can be regarded as the founder of the Saharanpur herbarium.

Duthie made the following special hot weather tours for botanical exploration and collection and the specimens obtained by him during these tours were incorporated in the herbarium :—

1877 to Jumnotri and the source of Jumna.
1879 to the Kedarkanta mountain in Tehri Garhwal.
1881 to Gangotri and the head of the Bhagirathi valley.
1883 to Gangotri, the Nila valley and across to Jumnotri.
1884 to Kumaon, West Nepal and the Tibet frontier.
1885 to British Garhwal as far as the Kuari pass.
1886 to Kumaon and West Nepal.
1892 to Kashmir and via Baltistan to Gilgit.
1893 to Kashmir via the Liddar and Sind valleys to Baltistan, across the Kargeh Pass and along the Kishenganga valley to Gurais and thence to the Deosai Plains by the Burzil Pass.

In addition Duthie visited several localities in the United Provinces, Rajputana, the Central Provinces and the Punjab and accompanied the students of the Forest School, Dehra Dun, on their tours in the Siwaliks, Dehra Dun, Jaunsar and Garhwal. He also accompanied the Black Mountain Military Expedition in 1888 and Inayat Khan and Harsukh, his collectors, accompanied the Chitral Expedition in 1895. Harsukh also made interesting collections in Gilgit and Waziristan.

As far as is known none of Roxburgh's specimens are represented in the Dehra Dun herbarium but there are a number of specimens collected in the Royal Botanic Gardens, Calcutta, which bear a label similar to those commonly found in the Wallich Herbarium and which are sometimes of great value in helping to determine some of Roxburgh's plants.

Many of the older collections made for the Calcutta Botanic Garden prior to 1842 are also in this herbarium. A few of Wallich's Nepal plants were recently received from the British Museum and others, occasionally bearing the Catalogue numbers, have been received either from Calcutta or from private collections such as that of Sir George King. There are also some specimens of Strachey and Winterbottom, Griffith, Helfer and Hooker f. and Thomson and a fair number of Stocks' specimens have come in with the Herbarium of Dalzell which was purchased jointly by Duthie and King. A set of Wight's South Indian specimens were received from Kew but it was not a complete one and more of his specimens have come with the herbarium of Dalzell. Some specimens of the earlier collectors like T. Thomson, Beddome and Falconer may also be seen in the herbarium and the following collections of the later collectors may be mentioned as being specially valuable and extensive :—

Col. Davidson, R.E., from Kumaon.

Dr. Aitchison, a complete collection of his Punjab plants. A nearly complete set of his Kurram valley specimens. A set of his Afghan Boundary Delimitation specimens.

Dr. Goodenough, this herbarium was received from Kew and contains specimens from countries other than India.

Sir D. Brandis, the greater portion of Brandis' herbarium was received from Kew.

Thwaites, a valuable collection of Ceylon plants.

C. B. Clarke, The Cyperaceæ and other specimens from various parts of India.

Sir H. Collett, from Simla, North-West Frontier and Upper Burma.

C. F. Elliott, Conservator of Forests, Punjab. Specimens from the Punjab and North-West Frontier.

A. V. Munro, from Hazara, Baluchistan and Multan.

C. W. Hope contributed many specimens of ferns.

W. Gollan, Superintendent of the Botanic Gardens, Saharanpur, from 1887 to 1904 collected extensively. He was mainly interested in mosses.

Cooke, an extensive collection of Bombay plants labelled ' College of Science Poona ' was received from Dr. Cooke.

Lisboa, grasses collected by Dr. Lisboa are frequently mentioned in the Flora of British India.

Gamble, from Bengal and later from Madras.

W. A. Talbot, Conservator of Forests, Bombay, contributed specimens from the Bombay Presidency.

J. H. Lace, from Baluchistan and the Punjab and later extensive collections from Burma which were supplemented by collections made there by various forest officers whom he interested in his work, like E. M. Buchanan and Maung Kyaw.

H. H. Haines, from the United Provinces, Bengal, Bihar and Orissa and the Central Provinces, collections made in connection with his ' Botany of Bihar and Orissa ' and ' Forest Flora of Chota Nagpur '.

D. O. Witt, in preparing his Descriptive List of the Northern and Berar Forest Circles, Central Provinces, contributed collections.
R. S. Hole, collections made during his tours as Forest Botanist in Assam, the Central Provinces, Mussoorie and Jaunsar.
A. E. Osmaston, from Dehra Dun, Ramnagar, Garhwal and extensive collections from Kumaon made for his Forest Flora of that area.
R. N. Parker, extensive collections from the Punjab, Chamba, Almora and Burma during the many tours made by him and numerous collections made during his stay in Dehra Dun.
Rai Bahadur Upendranath Kanjilal, extensive collections from Assam and Dehra Dun.
C. E. Parkinson, from the Andaman islands, Burma, Kulu, Jaunsar, Bengal and Chittagong.
H. G. Champion, from Almora and various parts of India during tours made by him as Silviculturist of the Forest Research Institute.
Dr. N. L. Bor, collections from Assam, Naga hills.

Numerous minor collections have also been received from the various provinces in India and from Burma from forest officers and others interested in the collection of plant specimens or in connection with their work. These are too numerous to detail here but the following deserve mention. From the Andaman islands collections made by B. B. Osmaston, R. L. Heinig, C. G. Rogers, King and Prain and their collectors: from Burma collections were sent in by C. B. Smales, C. G. Rogers, A. Rodger, especially Dipterocarps, and duplicates of the extensive collections made by the Forest Botanist and his collectors were supplied from the Maymyo herbarium. Kashmir collections came from Rai Bahadur Keshavanand and from W. J. Lambert. Specimens were sent from Coorg by H. S. Tireman and Madras collections by C. E. C. Fischer, A. W. Lushington and E. K. Krishnan. Some of Bourdillon's Travancore specimens are in the herbarium and the Conservator of Forests sent many from that State. Numerous students' collections have also been added to the herbarium as well as those made at Dehra Dun and the adjoining country by B. L. Gupta in connection with the revision of Kanjilal's Forest Flora and by M. B. Raizada in bringing Duthie's Flora of the Upper Gangetic Plain up to date.

The collections in this herbarium are not only confined to Indian specimens but numerous valuable specimens from all parts of the world have been obtained by exchange from other botanical institutions. The following are the chief additions made in this way.

*Russia.*—Central Asian and other plants from that country received from the Imperial Botanic Garden, St. Petersburg, later known as the Principal Botanic Garden, Leningrad.

*Switzerland.*—A valuable collection of plants largely material described in the Flora Orientalis was received from Dr. Boissier. Also specimens from other parts of Europe from the Botanic Gardens, Geneva.

*Philippines.*—Through Dr. E. D. Merrill valuable exchanges were made with the Bureau of Science, Manilla.

*America.*—By exchange with the Arnolds Arboretum numerous woody plants have been received including many of E. H. Wilson's Chinese collections. American plant specimens were also received from the Gray Herbarium and the New York Botanic Garden and from the latter institution a valuable collection of Dr. Koelz's North-West Himalayan plants were obtained.

*Japan.*—Japanese specimens from the Imperial University, Tokyo, Japan.

*Sweden.*—From the Botanical Gardens, Stockholm, and the State Natural History Museum Scandinavian plants including an extensive collection of Salix specimens determined by Floderus.

*Australia.*—From the Botanic Gardens, Sydney, and the National Herbarium, Melbourne, many Australian collections including a collection of Eucalyptus named by J. H. Maiden. Also a collection from the School of Forestry, Victoria.

*South Africa.*—A collection of South African plants from the National Herbarium, Pretoria.

*Revision of names by specialists.*—Amongst many others the collections of the following plant groups have been sent to specialists for study and naming thus adding very greatly to their value :—

*Mosses.* All the older Indian sheets were named by Dr. Brotherus of Helsingfors.
*Ferns.*—C. W. Hope spent many weeks at Saharanpur naming the fern collection.
*Characeæ* by H. and J. Groves.
*Aconitum* by Dr. O. Stapf.
*Cruciferæ* by O. E. Schultz.
*Impatiens* by Sir J. D. Hooker.
*Leguminosæ* by Sir D. Prain.
*Crassula* some of the sheets have been named by R. Hamet.
*Eucalyptus* most of the species cultivated in India have been determined by J. H. Maiden.
*Callistemon* by E. Cheel.
*Umbelliferæ* the naming of the plants in this family had been taken by H. Wolff but had not been completed at the time of his death though a great many were determined by him.
*Gentiana* by J. H. Burkill.
*Labiatæ* by Sir D. Prain.
*Plantago* by Pilger.
*Polygonum* by A. T. Gage.
*Euphorbia* by A. T. Gage.
*Ephedra* by Dr. O. Stapf.
*Dioscorea* by Sir D. Prain.
*Juncaceæ* by G. Samuelsson.
*Cyperaceæ* by C. B. Clarke and W. B. Turrill.
*Gramineæ* by Hackel.
*Bambuseæ* by J. S. Gamble.
*Rutaceæ, Aurantioideæ* by Dr. T. Tanaka.
*Avicennia* by Dr. H. N. Moldenke of New York.
*Ixora* and *Pavetta* by Dr. C. E. B. Bremekamp.
*Meconopsis* by Dr. F. Fedde of Berlin and G. Taylor of the British Museum.
*Corydalis* by Dr. F. Fedde.
*Taraktogenos* and *Hydnocarpus* by Dr. H. Sleumer.
*Dipterocarpus* by R. N. Parker.
*Terminalias* of the section *Pentaptera* by C. E. Parkinson.

The herbarium is housed in one of the large halls of the Forest Research Institute at Dehra Dun where there is ample accommodation for the collections and workers with room for expansion. The number of sheets is now estimated to be a quarter of a million to which about three thousand are added annually.

4. MR. V. M. CHAVAN, Poona.

*The Herbarium of the Economic Botanist to the Government of Bombay.*

The Herbarium of the Economic Botanist's section dates back to 1880. It was started when the Agricultural classes were held in the College of Science, Poona. The valuable collection is the work mostly done by Dr. T. Cooke, Messrs. G. A. Gammie, R. K. Bhide and H. P. Paranjpe.

The collection includes :—

(a) All the representative flowering plants of the Bombay Presidency and some of the Cryptogams—mostly ferns.
(b) Specimens of flowering plants collected and contributed from different parts of India.
(c) A large collection made by Mr. W. A. Talbot, Conservator of Forests, Bombay Presidency.
(d) A small collection, by the late Mr. Jayakrishna Indraji of Kutch containing some flora of Kathiawar.

There is no special officer in charge of the Herbarium but one of the Assistants of the Economic Botanist looks after it.

The Library of the Economic Botanist section as well as the Library of the College of Agriculture, Poona, is at the disposal of the Herbarium.

There is no special grant for exploration and upkeep.

(*Note.*—The herbarium was completely destroyed by fire in May, 1902. A fresh beginning was made by Dr. T. Cooke presenting his private collection to replace the one lost by fire.—S. P. AGHARKAR.)

5. DR. F. H. GRAVELY, Madras.

*The Herbarium of the Government Museum, Madras.*

The Madras Museum is the earliest botanical institution in South India. Even so early as 1878 its botanical collections were so crowded that necessity for more room began to be felt. It was at the Madras Museum that Surgeon Major G. Bidie prepared the *Flora Medica* of India. It was here that the famous collections of Wight, W. Elliot, Drew, Cleghorn, Beddome, Bidie, as also those of C. B. Clarke, Cameron, Bourdillon, Lawson and other pioneers were preserved. When C. A. Barber succeeded Lawson as Government Botanist in 1899 he moved the Government to have the herbarium transferred from the Museum to his charge at Ootacamund which was sanctioned. When Mr. Barber's head-quarters were moved to Coimbatore the herbarium was also shifted to Coimbatore.

With the popularization of botany in schools and colleges the need for a herbarium was keenly felt at Madras and a start was made again in 1920 to form a herbarium of local plants. A study collection was soon built up and an illustrated Flora of Madras City and its immediate neighbourhood was published in 1929.

The botanical gallery needed complete reorganization and this necessitated extensive collecting in South India, in which much valuable help has been received from Mr. E. Barnes, Professor of Chemistry in the Madras Christian College. Thus the beginning of a new general herbarium was made in 1921 and its specimens have been gradually increasing in number since, though of course nothing approaching finality has been reached. The staff consists of a single member, Mr. P. V. Mayuranathan, the botanical assistant who joined the Museum in 1920, with the assistance of one attender.

There is no special exploration grant, so the cost of touring has to be met from the small travelling allowance grant from which the tours of all the Scientific Assistants of the Museum have to be paid for.

The old museum library formed the nucleus around which the large and well-organized Connemara Public Library grew up in the Museum grounds. Though now primarily a public library it continues to cater for Museum needs.

6. MR. K. CHERIAN JACOB, Coimbatore.

*The Madras Herbarium.*

The Madras Herbarium was founded in the year 1874 by Mr. M. A. Lawson, a former Principal of the Presidency College, Madras. It was

first located in that College and was subsequently transferred to Ootacamund from where it was finally brought down to Coimbatore in 1910 on account of its dry and cool climate which is very essential for the proper preservation of the specimens. Dr. C. A. Barber, C.I.E., was associated with the Herbarium from 1900–1912 and contributed much towards the excellence of its collections. Later, Dewan Bahadur K. Rangachari, M.A., and Rao Bahadur C. Tadulingam, F.L.S., added much valuable material. At present Mr. K. Cherian Jacob, L.Ag., F.L.S., is in charge of the Herbarium under the administrative control of the Principal, Agricultural College, Coimbatore.

The Herbarium now contains about 85,000 shoots of specimens a large number of them has been authenticated at the Royal Botanic Gardens, Kew, and they include many types and co-types of representative South Indian plants. The collections of many eminent Botanists like Wight, Beddome, Gamble, Bourdillon, Bourne, etc. are included in the Herbarium. There is also a separate fruit and seed collection in addition to a collection of South Indian drugs. Materials for the preparation of the Flora of the Presidency of Madras by Gamble were supplied by this Herbarium. At present, materials for the preparation of the District Floras of the Presidency are being collected. About 100 new species were described from the material available in the Herbarium. Besides these, there is a wide variety of exotic collections from Cuba, Australia, South Africa, Federated Malay States, United States of America, etc. The economic section of the Herbarium contains a set of well-prepared specimens of all the South Indian varieties of Bananas and also specimens illustrating the life-history of most of the South Indian crops.

A small Library of about 200 volumes of well-known Floras is kept in the Herbarium for ready reference. Besides this, there is the General Library of the Research Institute containing about 5,000 volumes of botanical books and forming an easy source of reference to the Herbarium staff. The wall space of the Hall of the Herbarium is decorated with framed specimens of interesting and economic plants. About 70 varieties of ripe bananas are preserved in their natural colours and exhibited along with life-cycle charts and photographs of the same.

The staff of the Herbarium now consists of Senior Assistant Mr. K. Cherian Jacob, L.Ag., F.L.S., assisted by two Sub-Assistants and a Plant Collector. The post of the Government Systematic Botanist is now kept in abeyance. The present exploration grant is Rs.450 as against the original grant of Rs.3,000 in the beginning.

A small Arboretum and a Botanic Garden attached to the Research Institute form suitable adjuncts to the Herbarium.

7. Dr. M. Mitra, New Delhi.

*The Herbarium of the Imperial Mycologist.*

*Origin and history.* The inception of the Mycological herbarium of the Imperial Agricultural Research Institute, New Delhi, was made by Dr. E. J. Butler when he was appointed as the Cryptogamic Botanist to the Government of India in 1901. In 1905, Dr. Butler was transferred to Pusa as the Imperial Mycologist, and it was here that collection on an extensive scale from India was made and to which a large number of authentic specimens from foreign countries were added. In 1936, the herbarium was transferred to New Delhi when the Institute was shifted due to the Bihar earthquake of 1934.

The herbarium was started with a view to collect and identify parasitic fungi, specially those affecting plants of economic importance, so that the fungi of this country could be compared with those of other countries, thus enabling the experience and work of other countries to be utilized properly. It was also intended that this herbarium would afford to provincial workers a ready means of identifying the fungi unknown to

them, and in co-ordinating the work done in one province with that in another.

*Collections included in the Herbarium.* During the last thirty-five years the Section has accumulated a valuable collection of specimens of Indian parasitic fungi and has received in exchange from foreign countries such as the Philippines, Java, Straits Settlements, and also from Australia, New Zealand, Central Europe and the U.S.A. collections of parasitic fungi of economic importance in those regions. The collection represents about 750 genera and about 5,000 species. Apart from these fully identified specimens, there is a large collection of fungi whose specific determination has not yet fully been made.

*Staff.* The herbarium is under the supervision of the Assistant Mycologist who is helped by a junior assistant but more staff is urgently needed.

*Library.* The Section has been fortunate in gradually procuring a very valuable collection and it is regarded as the best library for the Mycological literature in India. It includes all the well-known current periodicals, books, monographs and floras. There is also a valuable collection of rare books and reprints. Some of these date back to 1816.

*Exploration grant.* Surveys were undertaken expressly for collection of specimens for the herbarium when the Section was started. Whenever tours are undertaken for the definite purpose of the investigation and observation of specific diseases, opportunity is taken to collect specimens from that locality for the herbarium. On account of lack of funds surveys cannot be done on extensive scale.

*Other features of interest.* In many cases, specially in fruits and vegetables and some aquatic fungi, the specimens are pickled in jars. Stages of pleomorphic fungi obtained in cultures are also pickled in fixatives.

A part of the activity of the herbarium is the maintenance of stock cultures of many pathogenic fungi. There are at present about 300 cultures obtained from various sources and are available for mycological workers in India and foreign countries.

A catalogue of all the specimens in this herbarium and their host index was printed and made available to the mycological workers in 1921. An up-to-date supplementary list is being prepared and will soon be available.

8. DR. S. HEDAYETULLAH, Dacca.

*The Herbarium of the Economic Botanist to the Government of Bengal.*

Collection and identification of the plants on and round the Dacca Farm began with the creation of the Dacca Central Agricultural Farm in 1909 by Dr. G. P. Hector.

There are about 5,000 specimens. The collections included in the herbarium are :—(*a*) Weeds of the cultivated fields, (*b*) Legumes and fodder crops, (*c*) Grasses of Bengal and Bihar, (*d*) Varieties of crop plants, (*e*) Varieties of paddies, and (*f*) Disease and pest infected crop plants.

There is no exclusive staff for the herbarium, but there is one preparer who makes the herbarium sheets and takes care of the specimens. The field staff (6) of the section collect material whenever necessary. The identification of the material is done by the Economic Botanist or by his Laboratory assistants.

There are about 25 volumes of Floras of India and her provinces. There is a proposal for acquiring Index-Kewensis and Pflanzen-Familien shortly.

There is no special exploration grant, but the Economic Botanist and his staff have a total travelling allowance grant of nearly Rs.7,000. They tour throughout the province and sometimes outside the province

as well. Interesting specimens are collected from different parts of Bengal and elsewhere during the tour.

The department has in view the building of a central agricultural museum at the Dacca Farm. In this connection a proposal has been made to set apart one spacious hall for a herbarium of agricultural plants. The special feature of the proposed herbarium will be to keep complete specimens of all the pure line strains and types of the various crop plants of Bengal and if possible of other provinces as well.

The present herbarium is being reorganized and attention is being concentrated on collecting the weeds of the cultivated fields of Bengal in order to study their botany with special reference to their ecology and reproduction.

9. Mr. T. S. Sabnis, Cawnpore.

*The Herbarium of the Economic Botanist (Oilseeds) to Government, United Provinces.*

As far as the teaching section in Botany is concerned, there is a small collection of specimens required for instructional purposes. Regarding Research side, I have an exhaustive collection of plant types of Agricultural crops representing different parts of India as well as the new types evolved either by selection or hybridization. The collections were made from plants grown with seeds received from different parts of India. The specimens pertain to the following crops :—Sun-hemp (*Crotalaria juncea* L.), Linseed (*Linum usitatissimum* L.), Rai (*Brassica juncea* H. f. and T.), Sarson (Brassica campestris, L.), Tori (Brassica Napus, L.), Safflower (*Carthamus tinctorius* L.), Groundnut (*Arachis hypogæa* L.), Til (*Sesamum indicum* L.), Jawar (*Andropogon Sorghu* Brot), Maize (*Zea mays* L.), Bajra (*Pennisetum typhoideum* Rich), Sanwan (*Panicum Frumentaceum* Roxb.), Manduwa or Nashani (*Eleusine coracana* Gaertn), Arhar (*Cajanus indicus* Spreng), Mung (*Phaseolus radiatus* Linn.), Urd (*Phaseolus Mungo* Linn.), Bhang, Ganja or Charas plants—*Cannabis sativa* L.

There is no special grant for maintaining the herbarium, but these collections were made for reference purposes from experimental crops.

10. Mr. M. Bhatia, Nagpur.

*The Herbarium of the second Economic Botanist, Government of the Central Provinces.*

The herbarium was started by Dr. R. J. D. Graham in 1908 for the use of the students, staff and research workers of the Agriculture Department, and nearly all the Angiosperms, i.e. indigenous plants of Central Provinces and Berar are in its collection. There is no separate staff maintained to look after the herbarium nor is there any separate library or exploration grant sanctioned for it.

11. Dr. T. C. N. Singh, Sabour.

*The Herbarium of the Economic Botanist, Sabour (Bihar).*

The herbarium consists chiefly of collection of plants from Bhagalpur District. It was started by the late Mr. E. J. Woodehouse, Economic Botanist to the Government of Bihar and Orissa sometime about the year 1910.

It consists of plants belonging to Angiosperms, Pteridophytes, Fungi and Lichens, etc.

There is no special staff attached to the herbarium.

A departmental library is being maintained.

12. Mr. S. L. Ghose, Lahore.

*Herbarium of the Government College, Lahore.*

The Herbarium of the Government College, Lahore, was started in 1915 by the late Professor S. R. Kashyap, D.Sc. Since then valuable collections have been made by members of the College and University botanical staffs, research scholars and students of advanced classes. There is no special staff to look after the Herbarium. All the plants are housed in the Government College Botany Laboratory and are under the direct supervision of the Professor of Botany of the College, who is also the Director of the University Botany Laboratory. Some of the collections have been made with the help of occasional grants from the College and from the University.

The following collections are found in the Herbarium :—

A. (i) A very rich collection of Angiosperms from Southern Tibet especially South-Western Tibet, comprising more than 200 species (excluding Cyperaceæ and Gramineæ), all properly labelled. This is perhaps the largest collection in the world for this area. (ii) A richly representative collection of flowering plants from the outer ranges in the Western Himalayas. (iii) A comprehensive collection of flowering plants comprising about 450 species from the Lahore District, properly named. (iv) A representative collection, also named, from the rest of the Punjab plain.

B. (i) A comprehensive collection of Ferns and their allies comprising about 75 species from Mussoorie and Dehra Dun. (ii) A rich collection of Ferns and their allies comprising about 100 species from Darjeeling, together with another 50 species from Sikkim, all properly named.

C. A rich collection of mosses comprising more than 200 species from the Western Himalayas and the Punjab plain, mostly named by Prof. Dixon.

D. (i) A comprehensive and properly named collection of Liverworts from the Western Himalayas and the Punjab plain comprising about 165 species. (ii) A richly representative collection of liverworts, properly named, from Darjeeling and Sikkim comprising about 100 species. (iii) Some 40 species of liverworts from South India. (iv) About 300 species of foreign liverworts, properly named.

E. A richly representative collection of Lichens comprising about 50 species from Darjeeling and Sikkim, properly named.

F. (i) A good collection of Indian fungi, especially of those forms causing diseases of plants. (ii) A rich collection of smut fungi and aquatic moulds. (iii) A large number of specimens of fungi imported from continental Europe and America.

G. (i) A fairly representative collection of freshwater algæ of the Punjab comprising about 250 species, properly labelled. (ii) About 50 specimens of marine algæ from Karachi coast and its neighbourhood, which are being worked out.

There is a library in the Laboratory in which botanical books and journals belonging to the College, together with some of those of the University are kept. About 1,900 volumes and 4 journals are housed here. There is also a University Library at a distance of about a furlong in which a fairly large number of botanical books are kept and some leading botanical periodicals are regularly subscribed for.

At present no exploration grant is given to the Herbarium from any source. The College and the University Botany Departments are maintaining the Herbarium with difficulty from their own funds.

13. Prof. F. R. Bharucha, Bombay.

*Herbarium of the Royal Institute of Science, Bombay.*

The total number of plants in our herbarium is 1,993 (phanerogams only).

There is no special staff.
Exploration grant : Rs.500 per year.

14. PROF. J. H. MITTER, Allahabad.

*Herbarium of the Department of Botany, Allahabad University.*

The Botanical Laboratory, Allahabad, was built in 1923 and its herbarium was started soon after.

The herbarium contains mostly specimens of fungi collected from various places in India (Naini Tal, Mussoorie, Simla, Darjeeling, Murree Dalhousie, Ootacamund, Almora, Allahabad, Khandwa, Majhgawan, Jubbalpur, Jullundar, etc.). Besides these, some ferns and Angiosperms have also been collected from the above-mentioned places.

A number of fungi and Angiosperms have been received in exchange from other countries.

There is no special staff for the herbarium except a herbarium bearer. A teacher of the Department, however, arranges the specimens and looks after them.

The Library facilities are not very satisfactory. There is only a small departmental library which mostly contains the books and journals necessary for teaching purposes. Books and journals have to be borrowed from other places.

The department is getting only Rs.200 a year for plant collection which greatly restricts our activities in this direction, often enabling us to visit only localities where we can be sure of getting material for class work.

A number of new species and 5 new genera of fungi have so far been described. Unfortunately some of the best specimens were available in very limited quantity.

15. MR. J. C. BANERJI, Calcutta.

*Herbarium of the Calcutta University.*

The Herbarium of the Calcutta University was started in 1921 by Prof. S. P. Agharkar with the specimens collected by him during his European tour in addition to duplicates presented by the Director, Botanical Garden, Berlin-Dahlem, as its nucleus. These collections included specimens from the South-West of France, Spain, the Pyrenese mountains, the Reviera coast, North Italy, Germany and Norway. A representative collection of mosses was purchased from Vienna and subsequently added to the herbarium by Dr. P. Brühl, late University Professor of Botany of the University. This is perhaps one of the best collections of mosses in India. A comprehensive and properly labelled collection of flowering plants and ferns from Chota Nagpur was presented by the late Rev. A. Campbell. A collection of duplicates from Malay, Sikkim, Andamans, Southern India and Godavari District received from the Royal Botanic Garden, Sibpur, has also been included in the herbarium.

Valuable collections made by Prof. Agharkar from Nepal, Khasi hills, Sundribans, Simla, Darjeeling, Deoban and Mussoorie have been properly labelled and added to the herbarium. Materials for a flora of the locality are being collected and determined by Mr. J. C. Banerji, Keeper of the Herbarium, Research Scholars and Students of advanced classes. A good collection of flowering plants, chiefly from Switzerland, was made by Prof. Agharkar during his European tour in 1935.

The following works of exsiccatæ were purchased and incorporated in the herbarium :—

(1) Migula's cryptogams (Algæ, Lichens and Mosses).

(2) Hupke Herbarium cecidiologicum.

There is a separate collection of interesting Indian materials preserved in fluid for a botanical museum. Owing to absence of funds for suitable show-cases and want of space in the laboratory, the collection is not being displayed properly. A fairly representative collection of Myxophyceæ of the locality has been made and properly labelled by Mr. J. C. Banerji. A good collection of local Characeæ has been properly named and a number of marine algæ from Krusadi island and its neighbourhood are being worked out.

The Staff consists of a Keeper of the Herbarium and a Plant Collector under the supervision of the Head of the Department of Botany. There is no exploration grant at present, but specimens are collected during tours undertaken with post-graduate students. The cost of local collections is being met from the departmental funds.

There is a good Library in the Department which includes many of the standard works on Systematic Botany and on the Indian flora. Most of the leading botanical periodicals are regularly subscribed for.

A small botanic garden has been recently started in the compound of the Botany Department.

16. PROF. M. SAYEED-UD-DIN, Hyderabad.

*The Herbarium in the Botany Department of the Osmania University.*

Proper collection and preservation of plants was started by Prof. M. Sayeed-ud-Din in the year 1931, but owing to several handicaps the progress was very slow till 1934.

Amongst the collections included in the herbarium are the local plants numbering 2,000, plants from British India about 200 obtained from the Royal Botanic Garden, Calcutta, British plants about 150, being the private collections of Prof. M. Sayeed-ud-Din and Dr. Hasain Ali Razvi, and Californian plants numbering 200 obtained in exchange from Mr. Lewis S. Rose of California.

There is no separate staff for the herbarium. Two of the members of the staff of the Botany Department are entrusted with this work.

The Library although it contains a good number of rare and standard works on floras is still poor. It is only since 1934 that it has been possible to build up a Departmental Library. Sixteen important journals are subscribed for.

Since 1935 four hundred rupees are sanctioned annually for touring expenses.

17. MR. S. H. PRATER, Bombay.

*Bombay Natural History Society, Bombay.*

The Bombay Natural History Society maintains no regular Herbarium. We have however in our Museum certain collections of plants presented by W. S. Birdwood, G. M. Woodrow and Major Macpherson. The collections include (*a*) Flora of Aden; (*b*) Bombay Flora; (*c*) Ferns of Ceylon.

No special staff is maintained to look after the Herbarium. It is in the charge of Mr. C. McCann, Assistant Curator.

Works on Botany include periodical journals on Indian Botany and publications from Kew. In addition there are a limited number of works dealing with the Botany of the Oriental Region. No special grants are made for Botanical Surveys.

Many important contributions on Indian Botany have however appeared and continue to appear in the Journal of the Bombay Natural History Society.

18. Sir Arthur W. Hill, Kew.

*The Indian collections at Kew, and the relations between Kew and Sibpur.*

The Herbarium of the Royal Botanic Gardens at Kew was founded in 1852 on the presentation of the important botanical library and herbarium of Dr. W. A. Bromfield by his sister. Actually, from the previous year Sir William Hooker's herbarium had been available for study, but it remained his private property until his death in 1865. In 1853 with the addition of George Bentham's herbarium the Kew institution was given a start which has brought it through continual accretion to its present outstanding position.

Botanical investigation had started much earlier than this in India, at least as early as the beginning of the 17th century when Edward Bulkley was attached as Surgeon to the Madras Establishment of the East India Company, while Van Rheede was preparing his great work Hortus Malabaricus on the other coast.

Regular botanical collection, however, received a special stimulus in 1768 when John Gerard Koenig joined the Danish Medical Mission at Tranquebar. This ardent botanist not only sent considerable collections to various Botanists in Europe, such as Linnaeus, Lamarck, Roth, J. Smith, Vahl, A. P. de Candolle, but greatly influenced others to similar activity, so much so that several of his friends, including J. P. Rottler, J. G. Klein and B. Heyne, banded themselves as 'The United Brothers' for the pleasure of the study of the flora.

Many new species were based on the specimens of these collectors by the botanists mentioned and others, including Koenig himself and, after his death, by his friend Dr. William Roxburgh.

Koenig bequeathed his own herbarium to Sir Joseph Banks and eventually it reached the British Museum in London.

Roxburgh was among those who came under Koenig's influence, and he eventually became the second Superintendent of the Botanic Garden founded by Lt.-Colonel Kyd near Calcutta in 1787. Unfortunately Roxburgh's Carnatic collections were lost in an inundation. His later collections, as William Griffith has pointed out, were incorporated without distinguishing marks with others accumulated at the Calcutta Herbarium.

The whole of these were taken to England in 1828 by the then Superintendent of the Gardens, Dr. Nathaniel Wallich, with the permission of the Court of Directors of the East India Company. To this large collection were added those which had reached the East India Company's Museum in previous years from Wallich himself, as well as the collections made in the Circars by Dr. Patrick Russell; by Rottler, Klein and Heyne in other parts of South India; by Dr. Francis Buchanan-Hamilton in various parts of India; in Siam and Cochinchina by G. Finlayson and by Dr. Robert Wight in the Madras Presidency. Wallich had spent some months in Nepal and besides collecting plants himself had instructed native collectors from whom he continued to receive plants after his return to Calcutta. The whole collection, now known as the Wallich Herbarium, was entrusted to Wallich to be divided into sets and distributed. This task, with the assistance of voluntary helpers, was accomplished between the end of 1828 and 1832. The sets were transferred to various European Herbaria, the chief one being presented by the Court of Directors of the East India Company to the Linnean Society of London.

No set came to Kew, for the simple reason that the Kew Herbarium, as we have seen, was not then in existence. At the end of 1832, before his return to India, Wallich sent the unsorted remainder to the Linnean Society with a request that the best obtainable set from it should be transmitted to Calcutta. This request remained unfulfilled for some time, but some twenty years later this remainder, together with some Indian

collections made by H. Falconer, W. Griffith and H. Helfer, and others by Helfer and Maingay from Malacca, which had been lying in the cellars of East India House, were made over to Kew and, after being sorted into sets, were distributed under a *Kew Distribution number*, together with those obtained by Joseph Dalton Hooker and Thomas Thomson in their expeditions in the Himalayas a few years earlier and the collections made for them by the latter's brother, Gilbert Thomson, in S. India, in view of the projected ' Flora indica ', of which only the first volume was published in 1855.

A good set of these was presented to the Herbarium of the Royal Botanic Garden at Calcutta.

I need not dwell at greater length on this aspect of the subject since a full account was given by Dr. Thomas Thomson, then Superintendent of the Calcutta Botanic Garden, in his note on the Herbarium of that institution published in 1856 in the Journal of the Asiatic Society of Bengal, Vol. XXV, p. 405.

I should also remind you of Sir George King's Address to the Botanical Section of the British Association held at Dover in 1899, when he gave a very comprehensive and most interesting account entitled ' A Sketch of the History of Indian Botany '. In this Address a full record is given of all the collectors who have enriched the Herbaria at Calcutta, at Kew and at the British Museum with Indian collections.

In 1913, owing to pressure of space, the Linnean Society of London offered the custody of its set of the Wallich Herbarium to the Kew Herbarium, where it is still housed in the fine mahogany cabinets in which it was kept at the Linnean Society; the duplicates from the remainder alluded to are incorporated in the general herbarium at Kew.

In subsequent years, further Indian material came to enrich the Kew collections in various ways; by gift, purchase or exchange. The most important of these are the collections of Strachey and Winterbottom from the Himalayas, a set of which was sent to the Calcutta Herbarium ; those of M. P. Edgeworth from North India ; of V. de Jacquemont obtained from French sources ; of Dr. R. Wight and Colonel R. H. Beddome,[1] both mainly from South India ; of J. E. T. Aitchison on the N.-W. Frontier ; of Dr. B. Schmid in the Nilgiri Hills ; of N. A. Dalzell and J. Stocks from Bombay ; of Colonel Collett in Burma and those made by Sir D. Brandis from various parts of India and Burma. In addition, C. B. Clarke, J. S. Gamble, J. H. Lace, J. R. Drummond and H. H. Haines presented their complete herbaria to Kew, each consisting of a very large number of sheets.

Kew has received also very large contributions from the Calcutta Herbarium and to a lesser degree from the Madras Agricultural College, the Forest Research Institute at Dehra Dun, and the Forest Departments of Travancore and Burma. Besides these sources, Kew has received contributions from a number of individual botanical collectors in various parts of India and Burma. Wherever possible the Calcutta Herbarium has been supplied with duplicates of interesting or new plants from these acquisitions and the intercourse between the two establishments has been mutually helpful and cordially reciprocal, thanks to the enlightened policy of the respective Superintendents and Directors, among whom I should especially mention Sir George King, Sir Joseph Hooker, Sir William Thiselton-Dyer, Sir David Prain and Lt.-Colonel A. T. Gage.

Besides the supply of herbarium specimens, Kew has been in a position to render considerable service to Calcutta in the determination during a period of years of a very large number of sheets by comparison with the types or with well-authenticated specimens. Facilities are always offered for the study of the Kew material and the following main floras have been compiled entirely or in part in the Kew Herbarium : ' The Flora of British

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[1] Beddome's first set of specimens is at the British Museum.

India' by Sir J. D. Hooker assisted by several botanists; 'The Flora of the Upper Gangetic Plain' by J. H. Duthie; 'Flora Simlensis' by Col. Sir H. Collett; 'Indian Trees' by Sir D. Brandis; 'Flora of the Presidency of Bombay' by T. Cooke; 'Flora of the Presidency of Madras' by J. S. Gamble, and the 'Botany of Bihar and Orissa' by H. H. Haines. Sir George Watt's 'Commercial Products of India', I may remind you, was also prepared at Kew.

For the purpose of the preparation of some of these works a large number of specimens were obtained on loan from the Calcutta Herbarium, the Agricultural College, Madras, and the Forest Department, Travancore. These were all scrutinized, the determinations checked and corrected whenever necessary and the undetermined ones named. Some of these, when the number of duplicates so justified, were retained with the permission of the responsible authorities, and the rest, comprising the great majority, were duly returned.

The recent visit to Kew of Mr. K. Biswas, the Curator of the Calcutta Herbarium, has been a welcome one, and with his collaboration a considerable number of sheets from the Kew Herbarium have been presented to Calcutta. Further duplicates will be set aside for Calcutta when a list of requirements has been prepared and sent to Kew. It is to be hoped that Mr. Biswas's visit will be followed by visits of other Indian Systematic Botanists and that the co-operation and friendly intercourse between our two great Institutions, which has lasted so long, with such fruitful results may become closer and of increasing value in the future.

19. Dr. F. R. Bharucha, Bombay.

*A Plea for the Revival of Provincial Botanical Surveys in India.*

A plea is made to establish Provincial Botanical Surveys in each of the eleven Provinces of India for the following reasons: (1) To be able to survey the vegetation of India; (2) For mapping of the vegetation which is not done so far in India; (3) For the formation of provincial, regional and local herbaria; (4) For the publication of Flora exsiccata; (5) For the collection of seeds, fruits, etc. for academic investigations of commercial value; (6) To serve as centres of special information to Medical, Chemical, and Pharmacological Institutes; (7) For propagation of knowledge for nature-study and creation of National Parks for preserving bits of natural vegetation. Lastly a few suggestions are made on the method of organization of such Surveys.

20. R. N. De, Shillong.

*Shillong herbarium.*

A serious effort to start a herbarium in Shillong seems to have been made from the year 1912 when Sir Archdale Earle, the then Chief Commissioner of Assam and the Government of India decided to publish a Flora for Assam. The late Rai Bahadur Upendranath Kanjilal, retired Extra-Deputy Conservator of Forests and an eminent Botanist was entrusted with the task of touring the whole province with a view to collection of plant specimens. A very comprehensive collection was made by him and it became necessary to maintain a staff for mounting and poisoning specimens.

Once a home was found for housing the specimens, collections began to come in from Forest Officers and others interested in the Flora of Assam and today there are more than 38,000 sheets and 2,000 wood specimens in the herbarium.

It would be, however, wrong to say that our collection began only from 1912, for we have got in our herbarium, sheets collected by that distinguished botanist Gustav Mann, in the year 1878.

The herbarium is now the most important centre for collection and identification of plants in Assam and receives many enquiries regarding their occurrence, supply and properties. In fact, the herbarium has more than justified its existence.

Although much useful work is being done, we are being constantly handicapped for want of adequate funds. The Botanical Forest Officer can hardly tour in the remote interior for exploration which is at present delegated to a herbarium mounter. The staff of the herbarium which consists of a Botanical Assistant on whom devolves most of the routine work, two mounters and two poisoners who are still on a temporary basis is hardly sufficient to cope with the increasing work.

No grant is earmarked for exploration, but the Conservator of Forests allots funds from time to time which amount to about Rs.500 per annum on the average.

The herbarium library is not large, but it contains most of the publications of old authors. Here again absence of funds is our handicap.

Volume I containing Parts I and II (Thalmifloræ and Discifloræ) of the Flora of Assam has already been published and Volume II (Calycifloræ) is in the press. Volumes III and IV are being prepared for the press.

Two numbers of the Forest records have been published by Mr. A. Das, (I.F.S. Retd.) containing the new plants of Assam and it is very likely that some more species new to Science will be discovered.

21. J. J. ASANA, Ahmedabad.

*The Gujarat College Herbarium, Bombay Presidency.*

*Origin and history:* The Gujarat College Herbarium was started by Prof. W. T. Saxton, M.A., F.L.S., I.E.S., I.A.R.O., in the year 1914. He was in sole charge of this herbarium till 1922. This herbarium came into existence mainly due to his efforts. He was assisted in his work by the late Mr. L. J. Sedgwick, B.A., F.L.S., I.C.S.

*The collections included in the herbarium:* The herbarium includes all the plants of Northern Gujarat, which have been systematically recorded in his paper 'Plants of Northern Gujarat' by Saxton and Sedgwick published in the Records of the Botanical Survey of India, Vol. VI, No. 7, 1918. It also contains a fairly large collection of plants from other parts of India specially Kashmir, Murri Hills, Mount Abu, Castle Rock and other places. There are about 3,000 plant specimens in the herbarium. Lately Mr. R. N. Sutaria, B.A., M.Sc., who is on the staff of the Biology Department, Gujarat College has added several interesting specimens of plants of South Gujarat.

No special staff or special library is attached to the herbarium. There is no special exploration grant.

22. SIR ARTHUR HILL, DR. K. P. BISWAS, DR. K. BAGCHEE, DR. M. MITRA, MR. NARAYANSWAMI, DR. K. C. MEHTA, PROF. BHARUCHA and others took part in the discussion. Prof. B. Sahni then summed up the position and requested Prof. Agharkar to make concrete proposals.

It was agreed that (1) there was a necessity for a National Herbarium in India, (2) that the Sibpur Herbarium should form the basis for this, (3) that it was necessary to strengthen the scientific staff of Sibpur, and (4) that the existing provision for 'Assistant for India at Kew' should be utilized for training personnel.

It was resolved to appoint a Committee of the following to prepare a workable scheme on the above basis and submit it to the proper authorities:

1. Prof. S. P. Agharkar, Convener.
2. Prof. B. Sahni.
3. Dr. K. P. Biswas.

4. Dr. K. Bagchee.
5. Mr. S. N. Bal.
6. Dr. K. C. Mehta.
7. Dr. M. Mitra.

Sir Arthur Hill was not included in the Committee as he was leaving India, but it was agreed that the Committee should work in consultation with him. It was further agreed that Brevet-Col. R. N. Chopra be also consulted whenever necessary.

The Committee has since met and forwarded its recommendations to the authorities concerned. A statement on the subject will be submitted to the 26th Session of the Indian Science Congress Association to be held at Lahore.

## XXVIII. THE DISSEMINATION OF CEREAL RUSTS IN INDIA.

*(Section of Botany.)*

PROF. J. H. MITTER presided, and PROF. K. C. MEHTA opened the discussion.

1. PROF. K. C. MEHTA, Agra.

*Opening Remarks.*

In the year 1923, the writer started a study of the factors concerned, in the annual outbreaks of rusts on wheat and barley in the plains of India. The present state of our knowledge on the subject is summarized below:—

(i) There is no local source of infection in the plains at the time of new sowings (October–November).

(ii) Weather conditions are quite favourable from October onwards yet no rusts appear at most of the places for as long as 3–4 months from the time of sowing.

(iii) Evidently rusts are re-introduced into the plains year after year from somewhere.

(iv) In contrast with the death of all uredospores in the plains, due to heat, after the harvest there is conclusive evidence of oversummering of all the rusts under study, in the hills.

(v) Year after year, rusts break out earlier and plant for plant there is heavier infection at the foot of the hills than at places farther off.

(vi) Still earlier outbreaks (November–December) have been found on the hill crops that are sown during October–November. In the case of early hill crops (sown April–June) rusts have been found during June–September.

(vii) As far as the plains are concerned, *Berberis* and *Thalictrum*, which occur only in the hills, seem to paly little part in the annual origin of black rust of cereals and the brown rust of wheat respectively.

Both these rusts break out year after year at the foot of the Nepal range and in the plains of Peninsular India during December–January i.e., 3-4 months before their alternate hosts which occur only in the hills, could ever get infected.

(viii) At the foot of the Nilgiris these rusts have been found to appear as early as September–October in miniature plots sown at the request of the writer during June–August

(4 and 2 months respectively before the normal crops). It may be pointed out that every year these rusts are found in abundance by August at altitudes of 6·7000 ft. in the Nilgiris on the first crop (sown April–June).

Since the year 1930 a good deal of work has been done on rust dissemination but the period of study is too short for an explanation of outbreaks in the country as a whole, at any rate, on the basis of wind trajectories. Still two important foci have been located wherefrom rusts spread to the plains.

Rust spores have been caught from the air on stationary slides, exposed in aeroscopes at a large number of stations in the country, long before the appearance of the rust in question on the local crops.

Nearly 8,000 wind curves have been studied so far, out of which a considerable number have been found to be significant. The course of such winds in the case of some of the stations is of special interest and points to dissemination of the rusts concerned from hill stations, where on account of oversummering and earlier sowings (April–June in the South and July–August in the North) they had been found in abundance a few weeks before.

Annual rust epidemics over large tracts of the country should be effectively controlled by stopping this *early* dissemination of rusts to the plains by the following means:—

(i) In Nepal, wheat and barley should not be sown anywhere before October.

(ii) The first crop of wheat and barley (sown April–June) in the Nilgiris and Palni hills should be suspended.

Rigorous destruction of self-sown plants and tillers of wheat and barley, on which rusts oversummer, 1–2 months before the sowings in all hills and hilly tracts should help considerably in the control of rust outbreaks in general.

The speaker showed lantern slides, maps, charts and wind trajectories in order to illustrate his remarks.

2. Prof. A. H. R. Buller, Manitoba.

In western Canada there are no Barberry bushes and yet the wheat is attacked every year by *Puccinia graminis*. The source of infection consists of clouds of uredospores which are carried by northerly winds for hundreds of miles from the middle-western parts of the United States to Canada. In the southern part of the United States, *P. graminis* overwinters in the uredospore stage. A proposal has been made to breed rust-resisting wheats suitable for growth in the wheat areas of the southern States and thus to prevent uredospores being carried northwards to Minnesota and the Dakotas subsequently from these States to western Canada.

I have listened with great interest to the account given by Professor K. C. Mehta of his work on the Rust Fungi of India done during the past fifteen years. The practical measures which he now recommends should, if carried out, very considerably decrease the incidence of the Rust disease in India and so add to the food resources of this great country. Professor Mehta recommends: (1) that in Nepal, wheat and barley should be sown in October instead of August–September; (2) that in the Nilgiri and Palni hills, the first crop of wheat now sown April–June, should not be sown at all, but should be replaced by some other crop; and (3) that in the hills in general, self-sown plants and tillers of wheat and barley should be destroyed 1·2 months before the sowings. All these recommendations seem to me to be wise and practical and I trust that the Government will see its way to carry them out, particularly No. 2, which would mean the suppression of wheat crop which is grown on only about 2,000 acres.

3. Dr. L. A. Ramdas, Poona.

1. If the source of rust was along the slopes of the Himalayas and of other mountain systems elsewhere in India, it is possible that the katabatic winds which flow down-hill practically every night in clear weather would convey the infection into the plains. During day time the anabatic (up-valley) air currents would carry the spores upwards and the chances of such spores infecting the plains would be more remote.

2. The spores conveyed into the plains by the katabatic winds would during day time be dispersed into the upper air layers by the diurnal convective movements. The problem is to find out whether particles having the size of rust spores will have a sufficiently rapid rate of settling to become sources of infection on a sufficient scale.

3. One process by which such settling down of rust spores in the upper air may take place quickly would be by means of rain-drops which can form on them whenever there is the necessary supersaturation in the upper air. If that happens it would be easy to account for some of the misfits regarding dates of incidence which are found by Prof. Mehta.

4. In all phenomena where questions like 'Source' and 'Dissemination' are involved one important fact to establish is the most usual variation of the factor in question with elevation above ground. Unless this is done it may be difficult to assess the relative importance of the different air layers as 'significant'[1] layers in so far as their disseminating power is concerned. Ordinarily, one may be led to expect that the nearer a 'significant' air layer is to the ground, the more likely the significance may be taken to be.

5. In investigations where 'coincidences' of certain factors are sought for in order to fit in two observed sets of data, it is important to remember that 'non-coincidences' should also be sought for without bias in order to bring out the relative importance of 'fits' and 'misfits'.

6. The cereal rust research in India under Prof. Mehta is one of the problems in which meteorology plays an important part. Prof. Mehta is to be congratulated on the success with which he has been working out the problem.

4. Dr. H. Chaudhuri, Lahore.

I have had opportunities of following Prof. Mehta's work and also discussing with him the problem several times during the last 10 years or so. I have no doubt that the incidence of rusts in the plain has no connection or perhaps very little connection with aecidiospores on *Berberis* in the hills. Again there is no doubt that rusts in an epidemic form occur earlier near the foot of the hills e.g., Pathankot, Gurdaspur, etc., in the Punjab, than places further away in the plains. We know also that uredospores from the previous years' crop cannot survive the heat of the plains and that viable uredospores are found in the low hills practically throughout the year. Prof. Mehta has proved by very convincing data how the spores from the hills are carried by the wind and bring about infection. He has also suggested very practical means of controlling rust—at least to an appreciable extent—by shifting the time of the wheat-sowing over a small area in the Palni and Nilgiri hills and by growing early ripening varieties in Nepal which are foci from which infections are carried over considerable areas. It seems very important to me that Government should as a test measure carry out Prof. Mehta's suggestions for a couple of years in the Palni and Nilgiri hill centres. If successful,

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[1] Prof. Mehta calls certain wind trajectories at particular levels which show evidence of having started from rust-infected regions as 'significant' trajectories. Such trajectories are found by him to fit with the sequence of dates of incidence reported from observing stations along the trajectory.

the amount of saving will amount to several million rupees. The Government and the people realize the huge amount of loss sustained by the country and I think this body of scientists who no doubt feel convinced about Prof. Mehta's work, should press the Government to take it up at once and try to save the wheat lost through rust attack, for the country. Prof. Buller has mentioned in the course of discussion that in 1914 by facts and figures and propaganda, he convinced the Government of his country that a huge amount of the food of the soldiers on wheat was being eaten up by the rusts and that some could be saved by eradicating the *Berberis* plants. Professor Buller has told us of the astounding fact that in a week's time, he was able to free his country from *Berberis*. Prof. Buller is very fortunate in coming from a country where people not only realized the gravity of the situation but worked accordingly to the advice tendered by the scientists. It is, however, all so very different in our country. If Government in our country worked according to the advice of the scientists and spent even a fraction of the amount lost through diseases for remedial measures, the condition of the people would be different. Prof. Buller emphatically stated that the measures suggested by Prof. Mehta were very practical and should be adopted without delay. He also said that breeding a wheat which would resist all the three rusts which occur over the greater part of this country was a very difficult job and was likely to take a very long time.

I am therefore strongly of the opinion that the Government of this country should take early steps towards necessary legislation so that the methods of control proposed by Prof. Mehta be enforced. It is of the utmost importance that as much of this colossal sum of money that is being lost every year be saved as possible. In the case of results of applied importance, it should not do to stop with a scientific report and I am sure this meeting will lend its fullest support to the views that have been expressed by Professor Buller and others.

5. PROF. K. C. MEHTA in reply to Ramdas's question regarding the importance from the statistical view-point of trajectories that have not been found to be significant, said that arrangements had been made for their examination by a statistician.

## XXIX. ALGAL PROBLEMS PECULIAR TO THE TROPICS, WITH SPECIAL REFERENCE TO INDIA.

### (*Section of Botany.*)

PROF. F. E. FRITSCH presided, and PROF. M. O. P. IYENGAR opened the discussion.

1. PROF. M. O. P. IYENGAR, Madras.

*Opening Remarks.*

The study of algæ, as compared with the other branches of Botany, is quite a recent one in India. For quite a number of years only a few botanists were studying the subject. I am very glad to find that more of our botanists are now taking to its study.

We are extremely fortunate to have amongst us today Prof. F. E. Fritsch, the world's foremost authority on algae. You may be interested to know that Professor Fritsch is not new to our country. He came to

Ceylon about thirty years ago and made a special study of the algæ of the place and has given in two valuable papers an excellent account of the algal ecology of Ceylon and also of the tropics in general. From my experience of the algal flora of India, I find that his remarks regarding the algal ecology of Ceylon are equally true in most respects of the algal flora of India also. I am sure, you all, like myself, are eagerly looking forward to hearing his valuable remarks on our algal problems.

*Lakes and Larger pieces of water.*

While the general characteristics of temperate inland waters have been very thoroughly studied by a number of very eminent algologists, the characteristics of tropical waters have not yet received the attention they deserve. Only a few tropical lakes have been investigated so far in some detail especially in Africa and in Java. But as regards Indian waters we may say that practically no work has been done so far.

The waters of temperate regions may be classified broadly under three main types, (1) the Oligotrophic, (2) the Eutrophic and (3) the Dystrophic.

*Oligotrophic lakes* are characterized by very great purity of the water with an extremely low mineral content and a very great clarity of the water, with the result that light penetrates to a very great depth in these waters. The dissolved oxygen is distributed more or less uniformly from the top to the bottom and the *p*H value also is uniform likewise throughout. The silt is very poor in quantity and the organic matter is very low and the small quantity of $CO_2$ that is present is found just above the silt. The colour of the water is bluish. The algal flora is very small in quantity though the number of species is fairly large. The algæ are distributed more or less equally from the top right down to the bottom and are able to flourish even in the lowermost regions, owing to the easy penetration of the light to that region.

*Eutrophic lakes* are characterized by a very high dissolved mineral content especially of nitrates and phosphates. The colour of the water is greenish-yellow and light does not penetrate very much into the deeper layers. The algal flora is very rich though the number of species is comparatively small. The amount of silt is very large at the bottom and the dissolved organic matter very high. The dissolved oxygen is found more near the upper portion of the lakes and the carbon dioxide is very large in quantity above the silt; and bacterial activity is very high in the lower regions. The *p*H value is higher above and lower near the bottom. The algal flora is more concentrated near the upper layers and during the midday there is a very great amount of supersaturation of oxygen owing to the assimilatory activity of the algal plankton. The plankton organisms keep continuously dying and falling the bottom of the lakes with the result that a large amount of silt continuously accumulates. Owing to the decay of the organisms at the bottom, the oxygen at the bottom layers is used up and a large amount of $CO_2$ accumulates in the region. Owing to the lack of sufficient light in the bottom layers and also the necessary oxygen the algal flora is very poor in the lower strata.

Coming to the *Dystrophic lakes* the waters of these lakes are characterized by the presence of a large quantity of humic acid and a great poverty of mineral salts. Even though the mineral salts are introduced into these waters from any source, they immediately combine with the humic acid and get precipitated to the bottom as insoluble compounds so that even though the mineral salts are there in the lake, owing to their insolubility, they are not available for the plankton algal organisms. The bottom silt is sufficiently large in quantity and the colour of the water is brownish to dark brown. The number of plankton algal organisms is small, and so also the number of species. Owing to the acidity of the water the bacterial activity is low so that not much of putrefaction takes place and the mineral salts available from the dead organisms do not return to the water.

Besides these three different types of lakes (viz. Oligotrophic, Eutrophic, and Dystrophic), a number of intermediate types are also described by various authors, but for our purpose it will be enough to accept only these three types.

In India, especially in the tropical portion of it, we do not have any large lakes like those of the temperate regions, but we have various types of smaller waters. It would be very interesting to find out how far these smaller pieces of water conform to the different types found in the temperate regions. So far as I have been able to find out, most of our waters here appear to be more or less eutrophic in character but detailed investigation is needed to decide the exact nature of the several waters. From what I have seen of them, it looks as though an entirely different kind of classification would be required for our waters. There is plenty of scope for the algologist for research in this direction.

Exact data are lacking as regards stratification and circulation in tropical waters. In temperate lakes, during the summer months the surface layers show the highest temperature and the temperature decreases downwards, the lowest temperature being found at the bottom. This decrease in temperature downwards is, however, not uniform. The temperature decreases steadily and gradually downwards up to a short distance from the surface and then there is a sudden fall, and then the decrease in the temperature is steady once again and more or less uniform right down to the bottom. The region where there is a sudden fall in the temperature is known as the *thermocline*, the region above the thermocline is known as the *epilimnion*, and all the region below it is known as the *hypolimnion*. Towards the approach of autumn the surface temperature gradually goes down. And, as the temperature goes down, the water in the surface layers becomes, owing to its lower temperature, bulk for bulk heavier than the water in the lower layers and so keeps sinking continuously downwards with the result that a sort of a convection current starts. This process goes on continuously until finally all the layers reach a uniform temperature of 4°C. As a result of this convection current a complete rotation takes place bringing about a total mixing up of the water of all the different layers. This is called the autumnal circulation. But as the season advances and winter approaches, the temperature of the surface waters becomes still further cooled down, i.e. below 4°C. But, since water at 4°C has got the maximum density, the water of the surface layers, when cooled down below 4°C, expands and becomes bulk for bulk lighter than the water of the lower layers, and the convection current stops. In the height of winter, the surface layers show the lowest temperature (0°C) and the bottom layers the maximum temperature (4°C). Here also there is a thermal stratification, but the stratification is the reverse of what is seen in summer, and is called an *inverted stratification* as opposed to the summer stratification which is called a *direct stratification*. In spring, the temperature of the surface layers goes above 0°C, and the water in the upper layers becomes bulk for bulk heavier than the water of the lower layers and so falls downwards and causes a convection current which continues until the whole body of the water reaches a temperature of 4°C. As spring advances and the temperature of the surface layers goes above 4°C, the convection current stops and as the season advances the upper layers become gradually warmer and warmer than the lower and by the beginning of summer a definite stratification (direct stratification) is finally established. Thus there are two periods of circulation, one in autumn and another in spring and two quiescent periods —a very long one in summer and a very short one in winter. These latter periods are known as the *summer stagnation* and the *winter stagnation*, respectively. During these two latter periods, there is a definite thermal stratification in the lake, the stratification being direct in summer and indirect in winter.

We do not know how far a similar thermal stratification over a fairly long period is present in our waters. Since the bottom temperature

in our tropical lakes of India never reaches 4°C, it being mostly about 12 to 15°C even in the coldest part in the year, the type of circulation that is found in the temperate regions is therefore not at all possible in our lakes.

Ruttner, while working on some lakes of Java, Sumatra and Bali islands, comes to the conclusion that a definite stratification is found in some of the deeper lakes and that a sort of a thermocline also is noticeable. Worthington Beadle, Hutchinson and Riccardo, while working on some tropical African lakes, have on the other hand come to the conclusion that no thermal stratification nor any thermocline could be seen in the African lakes that they investigated. Further careful work is needed to establish the question of stratification in tropical waters. In this connection it may be mentioned that S. V. Ganapati and myself observed a kind of stratification in the Red Hills Lake which supplies water to the Madras town. This lake is a very shallow one, its greatest depth being about 25 feet. In the early morning, the temperature of the water is uniform from top to bottom. As the day advances, the upper layers become heated up and are slightly higher in temperature than the lower ones and by about 2 P.M. a definite thermal stratification is established. But towards the end of the day, the water in the surface layers begin to cool and, becoming heavier than that of the lower layers, begins to sink down continuously with the result that, owing to convection currents, a definite circulation starts and continues throughout the night bringing about a complete mixing up of the water. By about the early morning, owing to this circulation, the water becomes more or less uniform in temperature in all its layers. The next day the same process is repeated again. Thus every day the water shows a uniform temperature from top to bottom in the early mornings. By about midday, a definite thermal stratification is established. As the evening approaches, the stratification is gradually broken up and before the next morning a complete uniformity of temperature is established once again. So there is seen here a daily formation of a thermal stratification in the course of the day and a daily breaking down of this stratification during the night. This type of stratification may be called a 'temporary diurnal stratification'. There is thus a daily building of a thermal stratification and a daily breaking down of this stratification, associated with a daily circulation which brings about a complete mixing up of the waters from top to bottom. The water of the surface layers, which owing to the photo-synthetic activity of the algæ gets highly super-saturated with oxygen in the daytime, reaches the bottom every day and the $CO_2$ produced at the bottom through bacterial activity is distributed to all the parts of the lake and becomes available to the assimilating plant organisms.

Miss Mercia Janet and myself investigated the waters of a small artificial tank in a garden in Madras. The tank was hardly 2 feet deep and we found the same sort of making and breaking of a thermal stratification, associated with a complete rotation every day.

How far this type of stratification is seen in various other pieces of water in India will have to be further investigated. Wind of course helps a great deal in bringing about a mixing up of the waters in the tropics as pointed out by Whipple, Ruttner, Worthington and others. This was observed in the Red Hills Lake also. On windy days the temporary diurnal stratification was invariably absent.

### *The Algal Flora of temporary Waters and their Succession.*

There are two kinds of temporary waters, (1) rain water pools which dry up after a very short time, and (2) small pools or ponds which dry up during the hot season. The rain water pools dry up generally within a short time after the stopping of the rains. These pools after a few days become very green owing to the very large quantity of algæ which come up within a very short time, causing a kind of water-bloom. The

algæ that are generally found in these waters are mostly members of the Volvocaceæ and with a sprinkling of a few members of the Protococcaceæ. If the waters of these rain pools become contaminated by sewage water a large number of Eugleninеæ also come in. These rain waters are rather interesting. Owing to the frequent intermittent light showers, these pools become filled up with water for a few days and then get dried up during the succeeding rainless days and again become filled up with water and then again become dried up. In this manner these pools become filled up and dried up several times and every time they get filled up with water it is interesting to note that the same algæ come up again and again, though towards the end the green algæ yield place to the Eugleninеæ and also to some blue-green algæ. It is rather interesting to note that blue-green algæ play a very subordinate part in these rain water pools.

As regards the deeper pools which retain the water for long periods and get dried up only during summer, they harbour a fairly rich algal-flora. If the water is not too much contaminated with organic matter they show a rich growth of green algæ including plenty of desmids. If, on the other hand, the water is rich in organic matter or is contaminated with sewage matter, blue-green algæ, Eugleninеæ, and diatoms preponderate. These deeper pools show all kinds of variations from nearly pure waters, through varying grades of organic contaminations to very badly polluted waters. A corresponding difference is seen in the nature of their algal flora. It would be very interesting to investigate these tropical pools in full detail and gather data regarding the correlation that exists between the nature of the water and the nature of the algal flora.

The algal succession in these deeper pools is very characteristic. The pools get filled up to the brim and often overflow the banks during the rainy season. When the water level begins to go down, the first algal forms to appear in the water are mostly Volvocaceæ. After a short time, other members of the Chlorophyceæ gradually come in. If the water should be fairly soft, desmids also become fairly noticeable. One marked feature is that during these early stages blue-green algæ are absent. If the water should be polluted in any way with sewage matter, then a certain amount of Eugleninеæ come in. As the season advances and the level of the water goes down a few blue-green elements come in and gradually increase in quantity as the temperature goes up and the water gets more and more concentrated. Towards the beginning of summer most of the pools become very nearly dry and by that time most of the chlorophyceæ disappear, the chief forms in the pools being blue-green algæ. Finally the pools dry up completely. This kind of succession, viz. green algæ first and then as the season advances blue-green algæ next, is seen not only in pools that dry up completely in summer but also in permanent pools which retain some water even during summer. The same kind of succession is seen also in the larger pieces of water such as irrigation tanks. Here also just before summer, the water is practically free from any green algæ, most of the algæ present being blue-greens and diatoms. This kind of succession has been very clearly described in detail by Fritsch in his very interesting account of the algal flora of Ceylon. Whether this kind of succession is due to the increased temperature or light intensity or to the increased concentration of the water or to other causes will have to be very carefully investigated. There is also just the possibility of the increasing organic matter of the water which accumulates through the continuous death of the plant organisms as the season advances, having some effect in determining this succession.

Another point in connection with these temporary pools which dry up completely in summer is that some of them harbour a rich desmid flora. Most of these desmids are able to form zygospores and are thus able to tide over the long dry period. This point is interesting, because there is a general belief among algologists that desmids cannot thrive in temporary waters, owing to the fact that they do not form usually zygo-

spores or resting spores of any kind quickly and so would be killed if the water should get dry. This is true of temperate climates where the desmids do not form zygospores quickly and where zygospores of several species are unknown. But in the case of the South Indian forms, my experience shows that a large number of desmids form zygospores very readily. In this connection it would be interesting to point out that Miss Rich found that some of the temporary pools of South Africa which dry up in summer harbour a large desmid population and that most of these desmids form zygospores very readily like our desmids and tide over the dry period and are thus well adapted to the conditions of the drying pools of that country.

Another very interesting phenomenon was observed by me recently. In a rain water pool in the Madras beach a species of *Cosmarium* came up suddenly in large numbers. The maximum depth of the water in the pool was only about a foot and the desmids formed a green layer about ½ inch thick at the bottom. One could practically scoop up the mass of desmids in one's hands. This green mass contained millions of this desmid and appeared like a thick green soup. When the water in this pool began to go down, I watched the desmids daily until the water completely dried up. When all the water disappeared, the desmids were still lying on the moist soil as a thick green gelatinous layer. An examination of a little of this material showed a few zygospores, but the main mass consisted only of vegetative individuals. As the soil began to get drier and drier, the gelatinous mass also gradually dried up into a thin brownish layer and finally crumbled into pieces and formed part of the soil. The desmid was watched as the gelatinous mass dried up gradually. All the individuals with the exception of a few which formed the zygospores gradually got shrivelled up and finally dried up in their vegetative condition only. Some of the soil containing the dried up desmids was put into fresh water and kept in the laboratory. The shrivelled up desmids became green and regained their original shape, but did not thrive long in the laboratory cultures and died finally. The point to be noted is the temporary revival of those dried up individuals when placed again in water. It would be interesting to find out whether in nature they are able to tide over the long dry period in their dried up vegetative condition. The fact that some of the individuals could revive after being dried up for a time is rather interesting from the point of view of their dispersal. According to the current view desmids are unable to cross ocean barriers since they will die very quickly if they are dried up in their vegetative condition and also because they form zygospores only rarely. But if desmids could form zygospores quite readily like our forms, if they could withstand a temporary drying up in their vegetative condition to a certain extent, it is quite possible for them to get dispersed by wading birds by being transported in the mud sticking to their feet, over long distances and also across ocean barriers which some of these birds are able to cross.

*Pieces of water with permanent water-blooms caused by species of Microcystis.*

In South India a large number of tanks and pools, especially in towns, are green throughout the year. They may be said to have permanent water-blooms. The green colouration is due usually to a single alga, generally a species of *Microcystis*, though frequently the *Microcystis* may be associated with planktonic species of *Oscillaria* and *Arthrospira.* These waters are slightly alkaline and are rich in organic matters and contain a large amount of chlorides. These tanks are utilized by people throughout the year for bathing purposes and the water does not appear to have any harmful effect on the bathers. Many tanks connected with temples have got this permanent water bloom. The algæ of these tanks seem to suffer, however, when the rainy season comes in and the sky remains

cloudy for a long period. They then begin to die and float up in large quantities, emitting a nasty smell throughout the rainy season. Their death is evidently due to lack of sufficient sunlight, as it is continuously cloudy for a fairly long time during this season. The water of these tanks during the greater portion of the year, owing to the assimilation of the algæ, is highly super-saturated with oxygen from top to bottom. It would be interesting to investigate these pools in detail especially in view of the fact that some of the blue-green algæ have been reported by several authors to be very harmful to animals drinking the water.

*Paddy-Field Algæ.*

The rice plant in our country is cultivated in the same fields for generations. In spite of this the yield of paddy continues, undiminished from year to year.

Every year a large quantity of nitrogen is removed from the soil in the shape of crops. A certain amount of nitrogen is put back into the soil in the shape of the crude manure that is applied by our agriculturists, but this is very small and is not sufficient to replace the large amount of nitrogen taken out of the soil. It is also known that the nitrogen content of Indian soils is very poor in quantity, though phosphates, potash, etc. are found in sufficient quantities to supply them over long periods. How in spite of all this every year the yield of paddy happens to be the same was not quite clear. During recent years, our biochemists (P. K. De, Sen, Viswanath and others) have been tackling this problem and have come to certain very interesting conclusions. Plenty of algæ are found in the waters of paddy fields and these algæ are found associated with nitrogen-fixing bacteria. These investigators think that the bacteria obtain some carbo-hydrates from the algæ and are then able to fix up the atmospheric nitrogen. This according to them accounts for the continuous addition of nitrogen to the paddy fields year after year.

Another group of workers (Dhar, Tandon and others) think that the paddy-field-soil itself is capable of fixing the atmospheric nitrogen without the help of any bacterial activity. The soil is able to do this through photochemical reactions in the presence of the carbo-hydrates supplied by the algæ. This view, however, is not very much accepted by the majority of the biochemists. In this connection it would be interesting to point out that Allison and Morris claim that the blue-green algæ themselves can fix up the atmospheric nitrogen without the help of any bacteria. How far this claim is justified will have to be decided by further investigation. Pure cultures of these blue-green algæ have been grown by some workers and it has been pointed out by them that the blue-green algæ in the absence of the associated bacterium is unable to fix up the atmospheric nitrogen.

Plenty of further research is therefore needed to decide how far the algæ are really helpful in maintaining the nitrogen supply of the paddy fields.

*Algæ of Estuarine Regions.*

The algal-flora of the estuarine regions is very interesting. The water during the flood season is mainly pure water, but during the rest of the year, when the flow in the river has stopped more or less, the water becomes gradually more and more brackish. Sometimes, near the mouth of the river, the water is nearly as concentrated as the sea-water itself. The algal flora, when studied throughout the year will show several interesting features. The algal flora of estuarine regions are studied in detail in western countries. G. Venkatraman and myself are now studying the diatom flora of the Cooum estuary at Madras during the several seasons. During the monsoon period when the water is practically pure the estuarine region contains only the pure water species. On the other hand, when the water is very brackish, quite a number of marine forms

come in and all the fresh water forms which were present previously die out. Some forms, however, are present more or less throughout the year under varying conditions of salinity. These forms are presumably those which can accommodate themselves to the increasing or decreasing salinity of the water.

We have plenty of estuarine regions in India. A study of the algal flora during the different parts of the year and the range of the different forms within the estuarine region and also higher up the river will throw much light on the capacity of the several organisms to adopt themselves to the varying conditions of salinity. It would be interesting to have exact data regarding the algal flora of our estuarine regions.

*Algæ in relation to aquatic animals.*

These can be classified under two important divisions: viz. (1) Algæ which are epizoic and are living on aquatic animals, and (2) Algæ as which form the food of animals. Quite a number of algæ living on the surface of the aquatic animals, for instance, some species of *Cladophora* are found growing on the shells of water snails, and some species of *Characium* on some crustaceans and some on Anophelene larvæ. These algæ by growing on moving animals are able to tap a larger supply of dissolved gases and salts through the movements of their animal host in the water. It would be interesting to note all such algal organisms that lead an epizoic life.

Coming to algæ as food of animals, it may be mentioned that algæ form the food of minute animalcules in the water and these tiny animals in their turn form the food of larger animals and these again of still larger animals and so on, until finally of the larger animals like fishes. Thus the fishes in the water really depend in a way though indirectly upon the algal population in the water for their food supply. It would be interesting to find out the nature of these 'food chains' i.e. from the algæ to the largest animals in the several pieces of water in our country. In pisiculture, this question is coming up largely to the front and investigations of such food chains in our waters will help materially in the development of pisiculture in the country.

*Algæ and Mosquito larvæ.*

Algæ are largely used as food by the larvæ of mosquitoes. Several workers have tackled this question. Rudolfs, Barbar, Buxton and Hawkins, Senior White, Lamborn, Hamlyn and Harris, Boyd and Foot, Howland, M. O. T. Iyengar and others. Two views are at present current regarding this question. One view is that the mosquito larvæ are specific in their food relations, i.e. that a particular species of mosquito larva depends for its food on a particular algal species and that in the absence of the alga or algæ in question the larva is unable to live. If this should prove to be the case, then it would be possible to control any particular mosquito by controlling the growth of the corresponding alga. The people holding the other view maintain that the mosquito will eat anything which comes in its way and that it is not specific in its food relations, and that, in the absence of the algæ, it will eat any other available food. And even, if a mosquito should depend on algæ it is not partial to any particular species or genus. Any alga is welcome and will form its food. So the two views summed up come to this: (1) that a positive correlation exists between the distribution of the mosquito larvæ and the distribution of the algæ forming their food, and (2) that there is no correlation between the distribution of the larvæ and the distribution of the algæ; if the algæ are present these are eaten by the larvæ. At present there appears to be more support for the second view. In India, the observations of Senior White on the feeding habits of the mosquito larvæ are more in favour of the latter view. In one case, however, a definite positive correlation has

been shown to exist between *Closterium* and *Anopheles punctipennis*, by Boyd and Foot. And a negative correlation was observed by them between Anopheline larvæ and Unicellular Cyanophyceæ. Another case of definite positive correlation has been recorded by M. O. T. Iyengar in Travancore. The larvæ of a species of *Mansonioides* live in pools in which *Pistia stratiotes* is growing in plenty. The larvæ, unlike other mosquito larvæ, do not come up to the surface to breathe, but dig their caudal portions into the roots of *Pistia* inside the water and get the necessary air from the intercellular air spaces found in the root of the *Pistia* and continue to live in that fixed condition. These pools, owing to the large amount of organic matter in them, support a rich diatom flora, and the mosquito larvæ live on these diatoms. An examination of the stomach contents of the larvæ shows a large number of diatoms in them. If the water in these pools is very pure and consequently poor in diatoms, then the larvæ are absent in the water.

2. PROF F. E. FRITSCH, London.

*Algal problems peculiar to the tropics.*

I have listened with great interest to the very able opening remarks of Prof. Iyengar and have been especially pleased to find that he has put the ecological point of view in the forefront of his considerations. There is no doubt that the study of the ecology of freshwater algæ is of considerable economic importance, and because this has been recognized in England we founded some ten years ago the Freshwater Biological Association for the study of the biology of freshwater plants and animals. This association has a laboratory on Lake Windermere in the north of England where many diverse problems of freshwater biology are being investigated. We have called our Association the Freshwater Biological Association of the British Empire, because we felt that many of our problems will find a parallel in other parts of the Empire and we should welcome the co-operation of Indian algologists in solving some of our problems. I have come here to learn from my Indian colleagues and do not want to say very much.

It is difficult to discuss all the numerous topics raised by Prof. Iyengar. A study of the algal flora of rice-fields seems to me most important. Here you have a unique artificial, but very ancient, type of habitat which has no direct parallel in temperate regions. What we want to know is how far there is a uniform type of algal flora (not necessarily extending to detailed specific constitution) in the rice-fields and how far it shows a uniform periodicity. To solve that, team-work on the part of investigators all over India is necessary. Such knowledge will help markedly towards the solution of the problem of nitrogen-fixation in rice-fields, which are still very unclear.

Prof. Iyengar referred to the characteristic features of tropical lakes and to the work of the German Sunda-expedition. This work has disclosed marked differences in thermal relations, oxygen-distribution, etc., in tropical and temperate waters and more particularly in those of the oilgotrophic type. In India, with its wide range of climatic conditions, these different types could be studied in detail and their exact relation to one another established. The small pools do not seem to me to be of the same degree of interest from the ecological point of view. As regards rivers I should like to see other parts than the estuaries investigated, as we know very little of the algal growth, apart from plantation, in tropical rivers.

Reference has been made to the abundant occurrence of water-flowers, usually due to *Microcystis aeruginosa*, in many of the small and shallow waters of South India. Organisms of this and similar types often cause analogous water-flowers in European waters, but this occurrence is not so regular and wide-spread. For many of them no means of per-

sistence from one period of occurrence to the next is known and yet during the period of 'absence' the persisting stages may perhaps be most vulnerable and most easily eliminated. Indian algologists can most readily study this question. At this point I may refer to the fact that for the majority of the Blue-green Algæ very little is known of the life-cycle, in particular of the numerous forms that occur in subaerial habitats in the tropics.

Prof. Iyengar also referred to the problem of the relation between mosquito-larvæ and the algæ of the waters in which they occur. I have seen collections of algæ from mosquito-infected waters from diverse parts of the earth; the algal flora is very varied and I know of no definitely established relation except that recorded by Dr. M. O. T. Iyengar.

3. Dr. H. Chaudhuri, Lahore.

It is doubtful if the algæ themselves fix any nitrogen. The author has examined algæ, water and soil from the water-logged rice-fields of Bengal. He isolated the algæ from the water-samples and also the soil. The algæ were mostly blue-green and some green. Algæ with mucous coat had always bacteria in the sheaths. The different bacteria were isolated, and grown in culture for determining the power of nitrogen fixation. Some fixed nitrogen vary quickly, others slowly. These bacteria were also isolated from the soil. The very rapid nitrogen fixation in rice-fields with algæ is due to these bacteria. In the ordinary soil, the fixation by these organisms is very slow, because they cannot multiply so quickly as when in the field the algæ are multiplying and disintegrating. These disintegrating algæ act as culture media when the nitrogen fixing organisms multiply very quickly.

Growth of algæ is determined to a very large extent by the salts present in the medium and in the fields, they act as indicators. In the Punjab, in many canal-irrigated areas, the water-table has been coming up and we find salts being deposited on the surface. When these salts are deposited, the normal algæ of the soil disappear altogether. Due to further siltage from the canals, these areas gradually become submerged in water for a few inches to a couple of feet or more. In this condition, I have noticed miles and miles of submerged lands, in which only *Hydrodictyon* and a few other algæ could grow. I have also followed the reclamation of these water-logged lands in the Punjab by treatment with gypsum, and gradually the return of the normal type of algæ. Algæ as indicators offer a fertile and useful field of research.

4. Prof. S. L. Ghose, Lahore.

(i) In the Salt Lake at Sambhar, Rajputana algæ form a pest and affect the quality of salt produced, and there is a tremendous loss of revenue to the Government. The algæ of the Lake should be studied and measures for their eradication should be investigated.

(ii) The morphological and physiological nature of the heterocysts of the *Myxophyceæ*. It has been observed that the contents of the heterocysts in the tropics are more abundant and more marked in tropical than in temperate countries.

(iii) Algæ can be used as indicators of the quality of soil, such as alkaline land that is being reclaimed by chemical means.

(iv) The question of river pollution by algæ is not so important in India as in England, as most of the rivers are larger and swifter. Moreover, the population round them is not so thick.

5. Prof. S. P. Agharkar, Calcutta.

I wish to have some information about the method by which the penetration of light into the waters of Indian lakes was measured. I further

wish to draw attention to the necessity of a study of the algæ of salt lakes of India. As regards the stage in which many of the algæ tide over the unfavourable season and why they are found at particular seasons only, there is very little information. This is the case with other organisms, including some animals, and it is desirable to investigate this.

6. DR. B. P. PAL, New Delhi.

Dr. B. P. Pal gave a brief account of some experiments he had carried out in Burma to investigate whether charophytes exercised a larvicidal influence upon mosquito larvæ. In these experiments plants of species of *Chara* and *Nitella* were grown in jars and known numbers of mosquito larvæ were introduced into some of the jars. The larvæ flourished in these jars just as well as in the control jars (i.e. jars in which no charophytes were growing). The results indicated that the species of charophytes experimented with had no larvicidal effect upon mosquito larvæ. In the course of the experiments it was discovered that the charophytes sometimes harboured the larvæ of a species belonging to the *odonata*, which preyed upon mosquito larvæ.

7. PROF. Y. BHARADWAJA, Benares.

Almost all the previous speakers have laid stress on the so-called economic aspect of the study of algæ on which practically no work has yet been done in India, and none has pointed out our difficulties in the morphological and taxonomic studies of these plants. While I strongly support that work on hydrobiology, limnology, pisciculture, etc. should be undertaken more or less on the same lines as followed in some of the foreign countries, I urge that the morphological study of these plants should not be neglected. We have not yet done much work on algology in India, and we must first know what kind of algæ grow in this country. The need for working out the algal flora of India is therefore imperative. This is a work of fundamental importance.

In order to know the species growing in this country we have at present to consult books on floras written by foreign authors. The descriptions of most of the tropical algæ given in these books are based on the study of preserved materials and they cannot therefore be considered entirely reliable. Algæ grow most abundantly in the tropical countries, and a sub-continent like India, with its varied climatic conditions and habitats, is the most suitable place for the study of these plants. My personal experience shows that in many cases species, even genera merge into one another through intermediate forms, and it is very likely that these are merely habitat-forms rather than separate plants. Such cases have been met with more abundantly in the *Myxophyceæ*, to the study of which I have devoted special attention, although they are not uncommon in the chlorophyceæ, such as the Ulotrichales, the Chætophorales and the Siphonales. I therefore strongly advocate a consistent study of the tropical algæ in the living condition from an ecological point of view to enable us to know their behaviour under different climatic and edaphic circumstances. I am sure such a study will bring out several interesting data which will nullify several genera and species that are at present recorded in books on algal floras written by those authors who had no opportunities of studying the algæ of the tropics *in situ*. In this respect the Indian algologists are in a position to contribute materially to the knowledge of these plants.

8. MR. R. SENIOR WHITE, Calcutta.

Though medicine has long recognized that it is essential to enlist the assistance of the entomologist in the solution of the problem of the

control of several insect-borne diseases, medicine has so far enlisted the assistance of the botanist only in the case of the disease trypanosomiasis. But with the entomologist, it is becoming very necessary that medicine should call on the algologist for help in the control of one, rather the principal, insect-borne disease of this country—malaria.

Malaria in the tropics will never be widely and generally controlled by the application of chemicals, for reasons of cost, and relief to the thousands of malaria-stricken villages in this and other tropical countries can only be looked for by the discovery and application of naturalistic methods of control, such as, from time to time, one sees nature herself apply to check the breeding of some malaria-carrying Anophelene. We are just beginning to make use of one or two of these naturalistic methods. The success of Ramsay's shade-methods in Assam, and of Williamson's herbage-packing method in my hand are cases in point. But we are quite ignorant of how such work. What change is caused in the water by densely shading it? Do we alter the flora on which the Anophelene feeds? Herbage-packing appears to act by de-oxygenating water, replacing algæ by fungi, but we lack any detailed chemical or botanical studies on the waters.

Taking seriatim the types of habitat discussed by Prof. Iyengar:

*Rain pools.*—I must disagree with Prof. Fritsch regarding their being of academic interest only. As a cause of malaria they are very important, in the North Centre of the country particularly. At times they produce the dangerous *culicifacies*, at others the harmless *subpictus* only, the reason appearing to be the amount of oxygenation, according to steady or to breaks in the rains. This lack of oxygen is not a direct effect on the larva, an air-breather. It is probably through the algal flora, an unstudied subject. I have published the algal study of an artificial rain pool, but that was only the start of such an investigation.

*Rice Fields.*—As Watson has said, food is even more essential than health, and therefore though rice-growing causes an enormous amount of malaria, it must continue. But all rice-fields are not malarigenous. Going from Calcutta to Madras they are so up to about the Orissa frontier, but not southward. Casual observation would suggest that this has something to do with the presence or absence of floating algal clumps (Chlorophyceæ), which are especially suited to *An. annularis*, the principal vector of the region. This algal growth seems less common in N. Madras. I would add my plea for the adoption of Prof. Fritsch's suggestion of detailed team-study of the algal flora of rice-fields.

*Estuarine areas.*—Here again I must join issue with Dr. Fritsch. The problems they present are not purely academic. They are highly important owing to the fact that they are the breeding ground of a special Anophelene, *sundaicus*, that has caused enormous suffering in deltaic Bengal, and is now a new-comer, causing havoc on the Chilka Lake. The problem of this Anophelene is very closely bound up with algal factors. It is probably a diatom feeder—diatoms turn the stems of the *Potamogeton* thickets brown but it is to the plaques of dead *Potamogeton* bound together by *Lyngbya* that the mosquito owes its prevalance and security from its enemies, fish, etc., living in the narrow crack-like water-space between the plaques. If the algologist will tell me how to control the *Lyngbya*, I will control the epidemic.

I once belonged to the school that thought mosquito larvæ selective in their feeding, but I do not now do so, though there well may be some algæ more nutritious than others, thus accounting for larval prevalence. But freshwater algæ have yet to be analyzed for food values, as have some marine ones. But there is one mosquito, *Culex bitaeniorhynchus*, that is entirely specialized, as its ventral plate shows, for feeding on one genus of algæ, *Spirogyra*. Williamson has recently shown that this mosquito, unique among the Culicines, is a vector of human malaria. Probably only academically so, but if there be found anywhere a place where this

mosquito is of any importance in malaria causation, then control of this malaria will be a matter of control of *Spirogyra*.

9. Mr. M. O. T. Iyengar, Calcutta.

Prof. Iyengar referred to the daily turn over of water in tropical ponds. I happened to make some observations, while studying the dissolved oxygen content of pond water, which appear to support his views. I observed that there is a diurnal variation in the oxygen content of surface water in ponds, which was highest at about 3 o'clock in the afternoon, and reached its lowest level in the morning at about 5 A.M. The rise in the dissolved oxygen content was associated with the solar radiation and the photosynthetic activity of the algal plankton. In the afternoon when the surface water (1″ to 6″ below the surface) showed a high dissolved oxygen content, the water at the bottom of the pond showed a low oxygen content. The surface water being warmer at the time, remained at the surface. The lowering of the atmospheric temperature after nightfall and the cooling of the surface water caused a circulation which resulted in the equalizing of the dissolved oxygen contents of surface water and deep water. From midnight till morning there was no difference in the dissolved oxygen contents of the surface water and deep water.

Prof. Iyengar referred to the work of Cabellero and others on the inhibitory action of *Chara* on mosquito breeding. I must say that the observations of Cabellero have not been confirmed by several of the later workers, and at present there is no evidence to show that *Chara* has any inhibitory action on mosquito breeding. Species of *Chara* with which I worked do not seem to have any harmful effect on mosquito breeding either in the laboratory or under natural conditions. I have in some cases seen numerous *Anopheles* larvæ thriving on the top of sub-aquatic brushes of *Chara*.

There are, however, a few algæ which appear to have some inhibitory influence. The presence of *Microcystis aeruginosa* in water appears to inhibit the development of most species of *Anopheles* with the exception of *A. subpictus* and *A. vagus*. I have also observed that ponds with a dense surface growth of *Euglena* are generally free from *Anopheles* larvæ.

There is another aspect of the influence of algal flora on mosquito breeding on which I have a few observations to make. Several species of mosquitoes of the genus *Anopheles* have specialized breeding habitats, some breeding in running water, some in seepages, some in brackish water, and others in fresh stagnant water. In many of these cases the selective habitat would appear to depend to a large extent on the availability of certain types of algal flora.

I give below two typical examples of the relation of algal flora to mosquito fauna.

In the foot-hill zone in Bengal the running streams are the important breeding places of *Anopheles*. Where these streams are covered with dense forest, the species of *Anopheles* found to breed are mainly *A. aitkeni* and *A. barbirostris*, species which are not concerned with the transmission of malarial infection. When such a stream is exposed to light, as for example, when the forest is cut down, the character of the *Anopheles* fauna is entirely changed. *Anopheles aitkeni* disappears completely and such species like *A. minimus*, *A. maculatus* and others known to transmit malarial infection breed in large numbers. The exposure of the stream to light causes a change in the algal flora, which inhibits the breeding of the harmless forest species and favours a heavy incidence of the malaria transmitting species. This change can be demonstrated by following a stream emerging from a dense forest into the open area. The differences between the shaded stream and the exposed stream as regards the algal flora and the anopheline fauna are indeed very striking.

This phenomenon has been utilized in malaria control work by preserving forests in the vicinity of streams and, where this is not feasible, by growing *Duranta* brushes on the sides of small streams to produce an artificial shade.

The second example relates to a mosquito known as *Mansonioides*, an important carrier of filarial infection in India. Unlike most mosquito larvæ which come up to the surface of water for breathing, the larvæ of *Mansonioides* has the interesting habit of inserting its breathing apparatus into the root of *Pistia stratiotes* and obtaining its supply of oxygen from the large air cavities in the cortical region of the root. Ponds covered with *Pistia* are generally poor in green algal plankton, and such green algæ as may occur are not available to the *Mansonioides* larvæ which leads a sedentary life attached to the roots shaded by the leaves of *Pistia* and an inch or two below the water surface. The food of the *Mansonioides* larvæ consists almost entirely of diatoms.

The occurrence of a rich diatom flora in ponds is closely related to the presence of some organic contamination, a common source being the decaying coconut husk steeped in ponds for the manufacture of coir. If such organic contamination is absent, the diatom flora is poor and *Mansonioides* fails to breed, although the other necessary factor, namely *Pistia*, is present. There is here a close relation between the presence of diatoms and the breeding of *Mansonioides*. The breeding of *Mansonioides* can be controlled by reducing the incidence of diatoms through eliminating the source of organic contamination.

Certain methods of mosquito control through altering the character of the water, as for example the herbage packing method, appear to be effective through the changes brought about in the algal flora of the water.

As a worker interested in problems connected with the ecology of mosquitoes, I cannot stress too strongly on the importance of studies on algal flora in relation to mosquito breeding.

### 10. Dr. F. R. Bharucha, Bombay.

The present discussion has brought out very clearly the importance of the inter-relationships of different branches of science for in the present discussion it is not only pure algologists who have taken part but doctors, entomologists, chemists, public health officers and ecologists. This interpendence of the subject is not realized in our medical research institutes like the Malarial Survey of India and Haffkine Institute, Bombay with the result that there are no posts of botanists in these institutes. Within the last one year several inquiries have come to me from such medical institutes for the identification of algæ and diatoms contaminating various types of waters. Industrial concerns and public health officers send their samples of contaminated water to such medical institutes and invariably due to an absence of a botanist on the staff, these inquiries do not elucidate any point. If a botanist is on the staff, he would do very useful work by analyzing the water samples from the point of view of an algologist and suggest means and measures to get rid of algal contamination or study these waters and make detailed ecological investigations with a view to find really profitable solutions for the prevention of infection by algæ and diatoms. Thus and thus alone, can the public health departments become really useful to the public. This point of the appointment of a botanist to the staff of a medical institute was also emphasized by Dr. Senior White, Malariologist to the Bengal Nagpur Railway who took part in the discussion.

### 11. Dr. Gilbert Fowler, Madras.

Dr. Gilbert Fowler (Madras) remarked on the importance of the study of Indian lakes as sources of water supply. In the past attention

had been confined to bacteriological pollution of water and the effect of storage on the viability of pathogenic organisms. Dr. Fowler had long urged the importance of limnological investigations, especially in relation to the water supplies of Bombay and Madras. The work of Prof. Iyengar and his colleague interested him greatly. From the economic point of view it was disappointing to hear that the problem of control of algal growth could not yet be considered to have reached a practical solution. The effect of the products of algal growth on the metal corrosive properties of the water was not properly understood. He would ask the investigators to study particularly the effect on algal growth of flow through closed conduits. In regard to effect of rate of flow of water on algal growth he would like to know what the critical rate of flow should be if danger of malaria was to be avoided. He must differ from the Chairman in his belief that the condition of Indian and European rivers was similar. It might shortly be said that in Europe there were large populations on small rivers, in India there were small populations on large rivers.

12. DR. K. P. BISWAS, Sibpur.

We are discussing a very vast subject on which very few of us have any comprehensive idea. I mean the discussion on 'Algal problems of the tropical countries of the globe'. Prof. Fritsch is the only authority here who can give us some idea from his early works on Ceylon and African algæ. But to tackle the various problems means continued study of algæ in different seasons in the field and in the laboratory, although, I admit there is some general similarity in the algal flora of the tropics as a whole.

It is better that we confine ourselves to the problems peculiar to India alone. Even then the study of the algal problems of such a large country as India with her diversity of climate is fairly a vast one. Again there are various aspects of the study of algæ. We have not yet taken even a census of the inland species belonging to the different classes of algæ occurring in all the provinces of India nor of all the sea weeds growing on the Indian coast. Some good work has been done in our country, but it is still very far from being complete. The systematic study of algæ which forms the background of all subsequent investigations is thus even now left far behind.

The study of algal ecology, both auto-ecology as well as syn-ecology, has also not been much attempted here. This is one of the most important subjects of study and has some bearing on economic aspects too. For example, we have -especially in Bengal and Madras—extensive rice-swamps. A systematic study of the algal ecology of these rice-swamps is of considerable importance to the growth of the rice crop. The amount of nitrogen fixation by these algæ is now being investigated by Mr. Dey in Prof. Fritsch's laboratory in London. The results of his studies will throw much light on this complicated question. Prof. Fritsch would further enlighten you on this subject. But, before taking up any detailed investigation in this direction, we must first of all know which different species of algæ grow in the rice-fields, in which area of the country, in what proportions and under what edaphic and climatic conditions. The capacity of each of these species to fix nitrogen will then disclose the usefulness or otherwise of the algæ growing in a particular rice-field. It has been found by Mr. Gardner of the Biology Department of Metropolitan Board, London, that the presence of certain members of the phytoplankton indicate an excess of certain mineral salts in the water in which they grow. Such discoveries are likely to improve the cultivation of rice in this country.

The importance of algal study in connection with the filter-beds of freshwater reservoirs has been emphasized by me in some of my publications both scientific and popular.

The importance of the study of freshwater algæ of tanks, jhils and lakes, particularly in a fish-eating country like Bengal, cannot be over estimated. Of equal importance is the study of the algæ of brackish waters like that of the Chilka lake, the Calcutta Salt Lakes, the numerous creeks of Sundarbuns and the extensive open water areas of Bombay along the sea-face which are the depository of many kinds of delicious fishes.

These are only a few of the problems and I have selected these as they have an applied side. The present question, as you are all aware of, is what is the use of this algal study?

We have plenty of material for pure study. For example, the whole of the Himalayan area is almost untouched. The recent collections of algæ made by me and others in the area show that there is no dearth of algæ even at a height of nearly 20,000 ft. The study of the occurrence of algæ at the different altitudes would be very interesting indeed. Then there are numerous hot springs even at a height of 17,000 ft. in Sikkim and in Garwahl Himalayas. It is worth studying the algal species growing around the hot springs in the hills and in the plains. We find also numerous ephemeral, annual, biennial and perennial species of algæ confined to the deeper depressions of the half dried river-beds in various parts of Northern India. They harbour quite a large stock of interesting algæ.

The study of the distribution of all the different types of even some of the common associations of algæ is also very fascinating

The physiologists and cytologists have yet to find out as result of their study, many important facts in the life-history of the various groups of Indian algæ.

To tackle all these problems requires men and money. We are certainly in want of the money if not in men. But, as regards Bengal and Madras, the study of the algæ of the rice-fields and the study of freshwater algæ of tanks and filter-beds are imperative. The Imperial Council of Agricultural Research, liberal as they are in encouraging every genuine attempt towards improving the crops, may be approached to provide funds for such a useful study. At least two or three research scholars can easily be provided. These scholars will work under the direction of an expert algologist. We shall therefore by such means have in the near future a band of trained algologists who, prompted by the interest of their study, will, I am sure, make algology a life-long study and would thus advance our knowledge of Indian algæ.

13. Prof. F. E. Fritsch, London.

*Concluding Remarks.*

As I said at the outset I have come here as a learner and I have indeed learnt much in this morning's interesting discussion. I have been particularly interested in the many contributions relating to the possible relation of algal growth and the occurrence of mosquito-larvæ and it is quite evident here that co-operation between the botanist and zoologist is desirable. The control of algal growth, whether in such waters or in water reservoirs, for instance, is however a matter requiring much further investigation. Very slight changes in the amounts of mineral salts or in the hydrogen-ion-concentration of the water may produce very marked changes in the algal growth present, and we are at present only at the threshold of understanding such changes. It seems probable that the control of algal growth will have to be attacked on a biological basis and that undue growth of algæ will best be checked by association with an appropriate fauna.

Some of my remarks were perhaps a little misinterpreted. I did not wish to suggest that the morphological study of the algæ be neglected, but that mere description of new species, until such species were known

to be of ecological value, was scarcely the best way of utilizing the abundant energy of the numerous workers on Indian freshwater algæ. How great a contribution Indian algologists can make to our knowledge of algal morphology is abundantly illustrated by Iyengar's work on *Tetrasporidium*, *Ecballocystis*, *Characiosiphon*, etc. and Bharadwaja's contribution on the morphology of the blue-green algæ.

## XXX. DISCREPANCIES BETWEEN THE CHRONOLOGICAL TESTIMONY OF FOSSIL PLANTS AND ANIMALS.

(*Sections of Geology and Botany.*)

Dr. A. L. du Toit presided, and Professor B. Sahni, president of the Botany Section, opened the discussion.

1. PROF. B. SAHNI, Lucknow.

*Discrepancies between the chronological testimony of fossil plants and animals.*

The question of a possible conflict between the evidence of plant and animal remains in fixing the ages of strata is not a new one, nor is it confined to the field of Indian geology. Like other many-sided problems it suffers from the inherent difficulty that the specialist has rarely, if ever, a full appreciation of evidence lying outside his own field.

Perhaps we shall never know how far our disagreements may be due to this factor. But the present occasion seemed to offer a unique opportunity for discussing our problem on broad lines, because we had looked forward to see here an international gathering of specialists representing different aspects of the question. For various reasons this hope has been only partially realized, hence our special thanks are due to those colleagues abroad who have sent us their views in writing although we could not have the benefit of their presence here to-day.

The sea has probably always covered the greater part of the earth's surface, as it does to-day. Accordingly most of our fossiliferous strata are marine, inspite of the great terrestrial formations of Gondwanaland in the south. As it was in the northern countries that the geological scale was first studied, our standard scale is primarily based upon marine animals, with the plant-bearing strata merely interpolated.

I have often wondered how a palæobotanist would classify the strata if he could possibly work on a clean slate, unfettered by previous ideas. In the Gondwanas, at least, he might quite probably place some of his major boundaries at horizons different from those in the European scale. But would this indicate a real discord in the age values of plant and animal remains, or would it be merely due to the well-known fact that in different parts of the world some of the major breaks in the rock-record occur at different periods?

The problem of these discrepancies, real or apparent, first confronted me about twelve years ago during a survey of the southern fossil floras, and I made a passing reference to it in an address to the geology section (*Proc. 13th Ind. Sci. Cong.*, 1926, pp. 246-247). Let us examine a few actual cases where the evidence from the two sources appears to be contradictory.

(*a*) *The Hawkesbury Series* (*N.S.W.*).—In Süssmilch's Geology of New South Wales (*3rd ed.*, 1922, p. 166) one reads of an astonishing

contradiction in the fossil evidence. The Hawkesbury series is generally included by the Australian geologists within the Trias.[1] The topmost member, known as the Wianamatta stage, contains a flora of Triassic (or Rhaetic) aspect, but of the eleven genera of fish recorded from St. Peters only four are said to be Mesozoic types, the rest being confined in Europe to the Palæozoic, in rocks ranging from Lower Carboniferous to Permian. In the accompanying table are indicated in parallel columns the broad affinities of the floras and faunas of the Hawkesbury series and related formations. It will be noticed that in the Hawkesbury stage (which is older than the Wianamatta) and in the Talbragar beds (which are younger) the fish are exclusively of Mesozoic types. *If the data are sound* we have here a predominantly Palæozoic fish fauna placed in the middle of a Mesozoic sequence, and associated with a Triassic or Rhætic flora. Whether the reported Palæozoic fish in the Wianamatta stage are really hold-overs or whether there is a flaw in the evidence is a question worthy of investigation.

| | Strata | Flora | Fish Fauna |
|---|---|---|---|
| | *Talbragar Series.* | *Jurassic.* | *(At Talbragar) Jurassic* |
| Hawkesbury Series | Wianamatta stage | Trias or Rhætic. | (At St. Peters) 7 genera Palæozoic, 4 Mesozoic. |
| Hawkesbury Series | Hawkesbury stage. | Trias or Rhætic. | (At Gosford) all Mesozoic. |
| Hawkesbury Series | Narrabeen stage. | Upper part Triassic. Lower part Permian. | |
| | *Newcastle Series.* | *Permian.* | |

Similar contradictions have no doubt come to the notice of others and one could easily multiply instances by a search through the literature.

(*b*) *The Lower Gondwanas of India and Australia.*—But perhaps the most remarkable example of the kind we owe to that distinguished geologist W. T. Blanford, who was perhaps the foremost amongst the several able men who during the latter half of last century laid the foundations of geological science in this country. After many years' intimate experience of the fossiliferous formations of India, and particularly of the Gondwanas, his deliberate opinion was that 'the Gondwana beds from top to bottom are of unusual interest on account of the extraordinary conflict of palæontological evidence that they present'. And he went so far as to say that if the plants were to be relied upon in the same way as the animals, then we would have in India 'a Rhætic flora overlying a Jurassic flora, and a Triassic fauna above both', and in Australia 'a Jurassic flora associated with a Carboniferous marine fauna, and overlaid by a Permian freshwater fauna' (*Rep. Brit. Assoc.*, 1884; *or Rec. G.S.I.*, *18*, p. 32 ff.).

The words I have just quoted were addressed to the geology section of the British Association at Montreal in the year 1884. They present to us in a nutshell the kind of attitude that geologists once held towards fossil plants as an aid to stratigraphy. Blanford's address was mainly devoted to an exposition of the many pitfalls that were then believed to lie in the path of the unwary geologist who might be tempted to employ fossil plants as a guide to stratigraphical correlation. To some of us

[1] Although palæobotanically the lower part of the Narrabeen stage cannot be separated from the underlying Newcastle series which is definitely Permian (*Sahni*, 1926, p. 245).

here to-day he may seem to have overstated the case. But we must remember that he was speaking a little over 50 years ago, when the prolonged and bitter controversy over the age of the Gondwanas had already come to a peak. From that controversy some of the foremost palæobotanists in Europe had come out with their colours lowered. McCoy and De Zigno, Saporta and Schimper, Carruthers and Bunbury, had all regarded our Damuda flora, and its Australian correlative the Newcastle flora, as Jurassic. The unfortunate fact was that in 1879 Schmalhausen (*Beitr. z. Juraflora Russlands., Mém. Ac. Sci. St. Pétersb.*) had assigned to the Jurassic an important collection of Russian plants which (as subsequent events showed) had come from mixed horizons, partly Jurassic, partly Palæozoic. A few of our Damuda plants had been identified and others closely compared with members of this supposed Jurassic flora, which also included tongue-shaped leaves recalling *Glossopteris* and *Gangamopteris*; and by some inexplicable process the whole of our Damuda flora was swept into the Jurassic net! The nearest resemblances were supposed to lie with the Lower and Middle Jurassic floras of Europe and here the superficial resemblance between *Glossopteris* and *Sagenopteris* must have helped in the deception. Feistmantel, it is true, had upheld an older age for the Damudas: he had classed them as Triassic but, as we know, even he had not gone far enough. Meanwhile the animal evidence in favour of a Permian age had become invincible.

I should imagine that fossil plants were never so much at a discount among stratigraphers as they were about the time Blanford wrote. No wonder that to a more or less marked degree geologists all over the world had a mistrust of plant remains. But in India this was a special pity because such a large proportion of our fossiliferous strata are freshwater deposits with plants as the chief basis for correlation.

Only gradually were the doubts cleared away. One after another were found, in distant countries like Brazil, South Africa and Australia, those few but sure links with the northern floras that we have learnt to value so much. And now we can say that, like the animals, the plants show our great southern coalbearing series to be Palæozoic. There never was any real discrepancy.

(*c*) *The Laramie problem* (*U.S.A.*)—American geologists are familiar with the long controversy over the Laramie problem, only recently laid at rest.

The question was whether the Cretaceous-Tertiary boundary line was to be drawn below or above the Laramie formation.

TABLE

(summarizing the Laramie problem).

| | |
|---|---|
| WASATCH<br>(Undoubted Tertiary) | |
| FORT UNION<br>Fauna very distinct from Laramie (no Dinosaurs); but flora regarded as closely allied to Laramie. | |
| LARAMIE (in its eastern part known as the LANCE)<br>Cretaceous fauna with Dinosaurs throughout but flora of modern aspect, regarded as Tertiary. | CANNONBALL<br>marine member interstratified with the LANCE. Rich fauna of strong upper Cretaceous affinities. |
| Undoubted marine Cretaceous. | |

The Laramie, in its eastern part known as the Lance, is a thick freshwater series containing a Cretaceous fauna with Dinosaur bones throughout, but also a flora which the early palæobotanists had pronounced Tertiary. The contradiction between the flora and fauna thus lay within the Laramie itself. Below the Laramie lie undoubted marine Cretaceous beds. Above it is the Fort Union formation with a flora reported to be closely allied to the Laramie but a very different vertebrate fauna devoid of all trace of dinosaurs (see Table).

If we go by the plant remains the Laramie and Fort Union should both be classed as Tertiary, and indeed in many places there seems to be a conformable passage between them. If, on the other hand, we give prime importance to the animal remains the Laramie (and Lance) are Cretaceous, the Fort Union is Tertiary; and this view is supported by the recent discovery (1922) of the Cannonball marine beds in N. Dakota which are interstratified with the Lance formation and contain a well developed fauna of undoubted Upper Cretaceous affinities.

Geologists in America now seem agreed to draw the line between the Laramie and the Fort Union formations, thereby giving greater weight to the faunal evidence, which obviously is very strong. A critical comparison of the two floras is therefore indicated to see if after all they do not fall into line with the faunas.

(*d*) *The Deccan Trap.*—A problem in some ways parallel to the Laramie was that of the Deccan trap formation which also turned upon the position of the Cretaceous Tertiary boundary line. The whole question was discussed at length at our Hyderabad meeting last year (*Proc. 24th Ind. Sci. Congr.*, 1937, pp. 459–471). So I shall content myself here with a reference to the salient points, so far as they concern the supposed conflict between the plant and the animal evidence.

The Deccan traps are a thick series of volcanic lavas covering an enormous area in the Indian peninsula. Direct evidence regarding their age is afforded by the flora and fauna of the so-called Intertrappean beds, an intermittent series of freshwater deposits laid down in lakes and rivers during the quiescent periods between the eruptions. Indirect evidence is given by the fauna of certain beds below, above and in distant areas but the exact relations of these beds with the traps are not always clear. This much is certain that in the Central Provinces the traps overlie strata of known Cretaceous age, viz. the Dinosaur-bearing Lameta beds, and the Bagh beds which contain a marine Cretaceous fauna. For the rest the field evidence is not clear. Near the west coast some traps are stated to underlie beds of nummulitic (Eocene) age. Still further off, in western Sind, a trap flow is said to lie below the Eocene Ranikot beds and above the *Cardita beaumonti* beds which are generally regarded as late Cretaceous; but the exact relation of this trap flow with the lavas of the Deccan is unknown. On the east coast, near Rajahmundry, certain other basalts are said to be separated by an unconfirmity from underlying beds containing *Cardita beaumonti*. A general view of the situation is diagrammatically shown in the accompanying scheme (this should not be regarded as a geological correlation table).

*Table showing the Deccan Traps and related formations.*

| | | | | |
|---|---|---|---|---|
| Ranikot beds of Sind Trap. | Nummulitics of Western cost Trap. | DECCAN | TRAP | Trap |
| | | Lameta beds. | Bagh beds. | *Cardita beaumonti* beds of Rajahmundry. |
| *Cardita beaumonti* beds of Sind. | | | | |

These and other facts have been so often discussed that it is difficult for us today to keep an untrammelled mind on the matter.

The pioneer geologists of a century ago had judged the traps to be early Tertiary, and in this they were largely guided by the intertrappean flora which included, *inter alia*, the characteristic Eocene fossil *Nipadites*. Even the associated fauna was then regarded as Tertiary (*Hislop, 1860, QJGS XVI, p. 165*) so that at that time there was no question of a discrepancy between the flora and the fauna. In subsequent years fresh-water fossils, and particularly plants, fell into disfavour with geologists. Even the evidence of the fauna does not then seem to have been taken seriously, and the question of the age of the Deccan Trap was again thrown into the melting pot. The direct evidence having thus been rejected as unreliable, there remained only a variety of indirect considerations, based partly upon dubious field evidence, partly upon the testimony of the animals in the associated strata. Largely through the influence of W. T. Blanford these indirect data, although admittedly inconclusive, were allowed to override the direct testimony of the flora. Thus in 1867 Blanford lent the weight of his authority in support of the Cretaceous theory. Before long this was adopted as the official view of the Geological Survey of India (*H. B. Medlicott and W. T. Blanford, Manual of the Geology of India, 1st ed., 1879*) and this has been for many years the view generally accepted by geologists both here and abroad. From time to time during the past sixty or seventy years attempts were made to revive the Tertiary view, notably in 1871 by T. Oldham (*Rec. Geol. Surv. Ind., IV, p. 77*), in 1884 by P. N. Bose (*see Proc. 24th Ind. Sci. Congr., 1937, pp. 461, 463*), in 1908 by Smith Woodward (*Mem. Geol. Surv. Ind., Palæont. Ind., III, pp. 1–6*) and more recently by others. But the faith of the Geological Survey in Blanford's judgment remained unshaken and in 1926 Sir Thomas Holland wrote (*Indian Geol. Terminology, Mem. Geol. Surv. Ind., LI, p. 88*): 'There can be very little doubt that the intertrappeans as a whole are Cretaceous, and this is very greatly strengthened by the occurrence of *Bullinus prinsepii* in the Mæstrichtian of Baluchistan'.

This was the position down to the end of the year 1933 when a comprehensive review of the intertrappean flora finally turned the balance again in favour of a Tertiary age, which apparently is now accepted by the Geological Survey. Not only were there individual genera of plants in this flora (*Nipadites, Azolla*, etc.) which strongly supported this view but the general character of the flora, with its great preponderance of palms, was distinctly Tertiary (*Sahni, Srivastava and Rao, The silicified flora of the Deccan Intertrappean series, Proc. 21st Ind. Sci. Congr., pp. 24–27, communicated Nov. 1933; Sahni, The Deccan Traps, are they Cretaceous or Tertiary, Current Science, Bangalore, III, pp. 134–136, Oct. 1934*).

In mentioning these details my main object is to emphasize that in fact there never was any real conflict between the plant and the animal evidence. We have seen that once it was decided that the plants were unreliable, the associated animals were thrown overboard with them, without any apparent reason. On the other hand, when the plant evidence reasserted itself, faith in the animals also revived. The whole history of this vexed question is an instructive example of the way in which the discrepancies, doubts and dissents of seventy years were dispelled once the evidence from one quarter became overwhelming. Not only did the animals on the whole support the plants but collateral evidence from radio-active data added its weight, while the field evidence educed by Blanford, never really convincing, now began to seem more dubious than ever. What is more, that oft-mentioned gastropod, *Bullinus* (*Physa*) *prinsepii*, so long ranked in India as a leading Cretaceous fossil, was now relegated to its real home in the backwaters of the Eocene.

(*e*) *The Po series of Spiti* is generally correlated with the Middle Carboniferous, and the grounds advanced for this are palæontological as well as stratigraphical. The greater part of this series, the *Fenestella* shales, contains a marine fauna presumably correctly assigned to the Middle Carboniferous, but geologists generally have ignored the fact that the basal part of the series, known as the Thabo stage, contains plants

which Zeiller had long ago compared with Lower Carboniferous forms. These plants have now been re-examined and their Lower Carboniferous affinities have been fully confirmed (*Gothan and Sahni, Fossil plants from the Po series of Spiti, Records Geol. Surv. Ind., 1938, LXXII, pp. 195–206*). So far as I know, there is no proved association of the flora and fauna in one and the same horizon, except that one rolled pebble which contains a well preserved leaf of *Rhacopteris ovata* McCoy sp., is said to have been collected from the *Fenestella* shales. The source of this pebble being doubtful, it would be wrong to assert that the flora and fauna co-existed in the Po series. There is thus no real contradiction between the two sources of evidence for the simple reason that they refer to distinct horizons in the series, and the plant evidence has since been supported on other grounds (*Fox, The Gondwana system and related formations. Mem. Geol. Surv. Ind., 1931, LVIII, p. 193*).

The Upper Gondwanas of India are generally subdivided into the Rajmahal, Kota, Jabalpur and Umia stages, exposed in widely distant parts of the country. It is generally assumed that the order in which they are named is based upon the affinities of their floras. This was no doubt the sequence originally suggested and it may be the correct sequence, but until all the floras have been critically revised the question cannot be regarded as closed.

Feistmantel had included all the four stages in the Jurassic. But in two cases (the Umia beds in Cutch and the Madras Coast beds) a conflict has arisen between the age as suggested by Feistmantel on the basis of the flora and that indicated by the marine fauna of associated beds. In both cases the animals indicate a younger age.

(*f*) *The Umia beds* are now considered younger than Jurassic because they are said to be interstratified with beds containing a marine fauna homotaxial with the Wealden. But the flora has never been revised since Feistmantel's time and all one can say is that so far it has revealed no characteristic Wealden species. Some further collections still await examination, and it is possible that the recent discovery of *Weichselia* and *Matonidium* in the neighbouring area of the Idar State (*B. Sahni, 1937, Rec. Geol. Surv. Ind., LVI, p. 152 ff.*) may be extended into Cutch. However, till the flora and fauna have been equally well explored it would be wrong to assert that there is any conflict of evidence.

(*g*) In the *East Coast Gondwanas* Dr. L. F. Spath claims to have discovered Lower Cretaceous ammonites and he suggests that the associated plant beds must be of a similar age. In doing this he revives a hint thrown out long ago (*Manual, Geol. of India, 2nd ed., 1893, p. 208*) that not only the Madras beds but even the Rajmahals may be younger than Jurassic. I do not know if Dr. Spath's evidence is of a conclusive nature, but no palæobotanist would contest it unless he knew that the flora contains a sufficient number of leading Jurassic forms, which is not the case. As the flora still needs a critical revision, it would be rash to assert that there is any real discrepancy.

But however justified Dr. Spath may be in referring the Madras coast gondwanas to the Lower Cretaceous there is certainly no ground for doing the same with the Rajmahal flora. This flora is now too well known, and contains too many forms directly comparable with Jurassic ones in other parts of the world, to admit of its being classed as Cretaceous. One cannot say the same of the Jabalpur beds of which the flora is not so well known and which also Dr. Spath refers to the Cretaceous. If, however, the Rajmahal flora is seriously regarded as Cretaceous then here, at last, we have a real conflict between the testimony of the plants and that of the animals. But is it safe to apply conclusions based upon the imperfectly known fauna of one region to the well known flora of another situated over a thousand miles away?

*Sources of Error.*—These few examples may suffice to show that the supposed discrepancies are in most cases due to our own mistakes. The sources of error are familiar to us all: imperfect collecting; wrong deter-

mination of species (often due to poorly preserved material); collections from mixed horizons being considered as one flora or fauna; conclusions drawn from one area or geological horizon being extended to distant areas or strata whose relations are not fully known; homœomorphic forms being considered as identical.

The responsibility of some of these sources of error is clearly established. Schmalhausen's supposed 'Juraflora Russlands' was a mixed assemblage from strata ranging in age from Palæozoic to Jurassic. We can scarcely say even today that we have completely got over the effect of this classical blunder. In the Po series there is no actual association of Lower and Middle Carboniferous forms, yet the age of the series as a whole was assessed solely on the preponderating fossil element, namely the marine animals in the Fenestella shales, in disregard of the flora in the basal part of the series.

Agreement as to what constitutes a 'species' is difficult enough to achieve in dealing with living forms; with fossil material it must be even more difficult. For stratigraphical purposes a narrower concept of 'species' is preferable to the wider. The use of comprehensive species ranging in their different component forms through a long geological period tends to prevent a classification of strata into chronological zones or ecological facies.

For a long time it has been commonly believed that marine animals are a better index of age than land plants, and the reasons for this view are well known. It is true that in several formations, e.g. the Jurassic, the flora appears more or less uniform through a long range of time whereas the same interval elsewhere is minutely zoned by marine animals. But it is important to enquire how far this fact is due to the inherent unfitness of plants as zone fossils and how far to our own lack of critical knowledge of the diagnostic features of plant-remains. At least so far as the Carboniferous is concerned the work of the Heerlen Congress has given ample proof of the value of plant remains in a zonal classification of rocks. Indeed, in a recent paper Professor Jongmans, to whom most of the credit for organizing this work is due, has even expressed the view that plants may sometimes afford a more satisfactory basis for correlation than marine animals (*Jongmans, Palæobot. Unters. i. Oesterr. Karbon. Berg- u. Hütt. Monatshefte, 1938 Bd. 86 Heft 5, p. 97*).

The fragmentary nature of plant-remains has frequently been urged against their employment in stratigraphy. But I venture to suggest that this very drawback places the student of fossil plants in a position of vantage over the palæozoologist. My point is that for each true species of large plants, such as a fern, cycad or conifer the palæobotanist often has two or three, sometimes four or five, artificial species to serve him as stratigraphical guides.

The fragments may be difficult to piece together and we may be a long way from gaining a picture of the plant life of the period. But here we are not concerned with that aspect. *So long as we know the fragments specifically, each of them will have the same age value as the complete plant.* To the stratigrapher it matters little whether a *Glossopteris* frond belonged to a *Vertebraria*, a *Ptilophyllum* to a *Williamsonia* or a certain *Sphenopteris* to a *Lyginodendron* or a *Lagenostoma*. To him any definitely recognizable fragment known to characterize a bed is a stratigraphical index regardless of its botanical affinities, although of course a knowledge of its affinities may be, and often is, an additional help.

The great thing is that we must know our fragments, and it is in this direction that modern palæobotany has recorded some of its most striking advances, particularly in the study of cuticles and of spores, both of which, I believe, are destined to rank among the most valuable aids to chronology. As I said elsewhere this morning (*Pres. addr. botany section, Proc. 25th Ind. Sci. Congr., 1938*) the facility with which spores travel across space invests them with special importance as zone fossils: whether of local origin or blown from afar they are equally useful as age indicators. Many

strata once regarded as unfossiliferous are already yielding valuable stratigraphical material under the microscope. The future of micropalæobotany as an aid to stratigraphy is thus fully assured.

2. Mr. D. N. Wadia, Calcutta.

Instances of discrepant testimony of plant and animal fossils in the correlation of Indian formations are :—

(*a*) The Po series of Spiti Himalayas—fossil fern like plants of Lower Carboniferous (Culm) age associated with a marine fauna of Middle Carboniferous age.

(*b*) The Agglomeratic Slate series of Kashmir—a Productid fauna, earlier than that of the Lower Productus Limestone, along with species of *Gangamopteris* and *Glossopteris* whose affinities may be with the Permian (Damuda) of East India.

(*c*) The Gondwanas of the East Coast—containing ammonites, described as of Upper Neocomian age, side by side with a fossil flora whose Middle Jurassic affinities are insisted upon by many observers, on the ground of its stratigraphic position as well as on the evidence of associated fish and reptilian remains.

(*d*) The Deccan Inter-trappean beds—containing a flora with a preponderance of Palms, (along with fossil fishes), indicating Eocene affinities, in the lower part of the traps of Nagpur, while the abundance of reptiles in the conformably underlying infra-trappean beds (Lametas) of adjoining localities indicates a Cretaceous age; the latter occurrence is in keeping with the Wealden flora (*Matonidium, Weichselia*) of the Idar sandstones forming the floor of the Lameta-Trap succession.

These discrepancies, except in the case of (3), it must be admitted, are of comparatively minor significance and can probably all be accounted for by the accidents of collecting of the fossils, the varying conditions of sedimentation, bad preservation, etc. There is also the important consideration of a lag in the rate of evolution of plant and animals in distant quarters of the earth and the possibility of the association of a Middle Jurassic land flora with a Lower Cretaceous marine fauna in some secluded and barricaded terrestrial area. Stratigraphic data, carefully collected in the field, should be given prime importance in dealing with cases of discrepant testimony of plant and animal fossils in a stage or series.

3. Dr. M. R. Sahni, Calcutta.

*Are there discrepancies between the evidence of plant and animal fossils?*

Absolute synchronism between the minor subdivisions of the geological scale cannot always be expected in the case of strata in widely separated regions, but whenever fossils have been reliably identified, the palæobotanical and palæozoological data mutually support, and do not conflict with, each other. At any rate the discrepancy is not greater than sometimes exists in the case of certain formations correlated on the basis of animal or plant fossils alone. For example, according to Dr. Spath (*Meddelelser om Grönland, LXXXIII, p. 79, 1930*)—

> 'It is even possible that the *Ophiceras* layer of Pastannah in Kashmir is not synchronous with the zone of *Ophiceras tibeticum* at Painkhanda, for the commonest ammonite of the *tibeticum* zone of the Himalayas was very rare in Kashmir.'

And yet the synchronism of the *Ophiceras* beds in different regions is accepted. The discrepancy here is, I think, easy to explain if we remember that we may be correlating younger with relatively older horizons *within the same zone* or *vice versa*. A zone may be represented by twenty feet of

strata in one locality and only two in another. Even making allowance for the assumption that the rate of depositon may be slower in some than in other regions, we can hardly assert that the two feet of strata in one locality span an equal period of time as the twenty feet in another, in spite of the presence of the same zonal fossil in both.

Thus the *Ophiceras* beds of one area may, but need not necessarily, be absolutely synchronous with the *Ophiceras* beds of another area.

To give an instance of even more serious conflict, the equivalents of the Namyau series, which have been regarded as Upper Jurassic on palæontological evidence by various writers, including the present (*Rec. Geol. Surv. Ind., 71, Pt. 2, pp. 217–230, 1936*), are assigned, likewise on palæontological evidence, to the Upper Trias by the French geologists in Indo-China (*M. Fromaget: Bull. Surv. Geol. Indocohine, XVIII, Fasc. 5, pp. 19-20, 30, 1929*). The discrepancy covers practically a whole system. It is in my opinion the result of misidentification of fossils and of insufficient evidence. Yet, in fairness to the palæontological record, it must be said that where such evidence is complete, the faunas are remarkably similar, even in distant regions. I think no more striking instance could be cited than that of the *Calceola sandalina* zone faunas of Eiel and Padaukpin (Northern Shan States) which, separated by 90° of longitude and 35° of latitude, are unquestionably identical. This is due to the fact that the faunas in these regions are exceptionally well-preserved, prolific and therefore reliably identifiable. Undoubtedly palæobotanists can cite similar instances in their plant record.

The conclusion is that the existing discrepancies are not inherent in the available evidence but are due to the imperfection of the geological and palæontological or palæobotanical record or to the interpretation thereof. They are based upon premises and determinations which cannot always be accepted without reserve, and I shall endeavour to illustrate this with reference to three important Indian formations—the Deccan Trap, the Gondwana rocks and the Po series.

## 1. The Deccan Trap.

In dealing with the Deccan traps many of the arguments advanced in favour of their Tertiary, or against their Cretaceous age, will necessarily have to be reiterated, but I shall hope to do so from a slightly different angle to the arguments generally advanced.

### *Palæontological evidence in favour of a Cretaceous age examined.*

(*a*) *Physa* (*Bullinus*) *prinsepii*.—

An important factor in assigning a Cretaceous age to the traps is the occurrence of a supposed *Physa* (*Bullinus*) *prinsepii* in the Cretaceous rocks of Baluchistan, it being the leading fossil of the intertrappean beds in the Deccan. My brother Prof. B. Sahni, attaches little importance to the evidence of this fossil from Baluchistan (*Proc. 24th Ind. Sc. Congress, General Discussion. The age of the Deccan Trap, p. 466, 1937*). Although I am in agreement with him in his conclusion, my reasons for doing so are different.

This is the only record of this species in Cretaceous strata, and has been used by Sir Thomas Holland in favour of the Cretaceous-age-theory for the traps. He writes:

> 'There can be very little doubt that the intertrappeans as a whole are Cretaceous, and this is very greatly strengthened by the occurrence of *Bullinus prinsepii* in the Mæstrichtian of Baluchistan'. (*Mem. Geol. Surv. Ind., LI, p. 88, 1926*).

In reading the account of the circumstances under which the Baluchistan specimens were recorded, I feel convinced that their identifica-

tion by Vredenburg (*Rec. Geol. Surv. Ind., XXXV, pp. 114–118, 1907*) is extremely doubtful.

This fossil was collected by Noetling, yet Noetling himself does not mention this important occurrence in two accounts which he wrote of the stratigraphy and palæontology of the Des Valley, whence the supposed *Bullinus* was reported to have been collected (*Gen. Rept., Geol. Surv. Ind. for 1898-1899, pp. 51–63, and Centralblatt für Min. Geol. und Pal., for 1903*). Noetling gave lists (incomplete according to Vredenburg) of the fossils collected by him, and it would indeed be remarkable if the most important fossil had escaped Noetling's critical eye. Furthermore, Vredenburg remarks upon the small size of the specimens from Baluchistan, as compared with the normal type found in the intertrappeans. Nor does Vredenburg figure this important find, and all my efforts to trace the specimens in our Museum collections have been futile, although other specimens from this locality were registered and may be seen in the Geological Survey collections.

In the circumstances I think that this identification cannot be accepted and the occurrence of an undoubted *Bullinus prinsepii* of the intertrappean beds, in Cretaceous strata, has yet to be demonstrated. The specimens from Baluchistan may belong to some diminutive species of *Bullinus* or to some closely allied genus.

An important argument in favour of the Cretaceous age of the trap, therefore, falls to the ground. At the same time the value of the association of this species with Tertiary plants is enhanced, thus obviating the supposed discrepancy.

(*b*) *Cardita beaumonti.*—

We may now examine the evidence of another important fossil, *Cardita beaumonti*. This fossil occurs interstratified with the lava flows of Sind. The Cretaceous age of the main Deccan Trap was based on an unwarranted assumption, that the Sind traps represent the youngest and not the oldest flows. Moreover, there is still doubt whether this supposed flow is not in fact a sill. Since the *Cardita beaumonti* beds rest both above and below the trap ( ?) it was assumed that the whole of the Deccan trap must be of Cretaceous age. This assumption is undoubtedly influenced by the fact that these beds are overlain by Eocene rocks. Sir Thomas Holland (*Mem. Geol. Surv. Ind., LI, p. 64, 1926*) states on the authority of Vredenburg (*Rec. Geol. Surv. Ind., XXXV, 180, 181, 186, 1908*) that

> 'In geological age the Deccan traps range from soon after the formation of the Lametas (*cf. C. A. Matley, Rec. Geol. Surv. Ind., LIII, p. 162, 1921*) of about Cenomanian to Aptian age up to the end of the Cretaceous epoch, basalt flows in Sind being found between the *Cardita beaumonti* beds of Mæstrichtian age and below Lower Eocene beds.'

It should be borne in mind that a fossil gives the age of the containing bed only, not of what lies above or below it, or in other areas. Therefore if we can be sure of one thing, it is that the trap in Sind (assuming that it is not a sill) is of Danian and pre-Ranikot age, but it does not enable us to establish its position with reference to the main trap of Central India, that is, whether it is contemporaneous with the oldest or youngest flows of the latter. *Moreover Cardita beaumonti has not been found associated with any fossils, plant or animal, which are confined to the Tertiary. We can therefore state that just as the association of Physa (Bullinus) prinsepii with a Cretaceous fauna has not been demonstrated so also the occurrence of a definitely and exclusively Tertiary fauna or flora with Cardita beaumonti has not been established.* The evidence of *Cardita beaumonti* does not therefore prove a discrepancy. But palæobotanists will have to admit that volcanic activity, as pointed out by Prof. L. Rama Rao (*Proc. Ind. Acad. Sc., IV, No. 3; Sec. B, p. 219, 1936*), had already

begun in independent centres, in Western Sind and Rajahmundry, about the close of Cretaceous times.

The foregoing arguments may, however, be regarded as more or less negative evidence. But Hislop has, in no mistakable terms, expressed his opinion in regard to the age of the intertrappean fauna, both vertebrate and invertebrate, as well as the flora. He compares certain intertrappean fossils with those from the Nummulitics of Western India, and species of *Turritella, Natica, Physa, Vicarya* and *Cerithium* wih those from the Eocene deposits of Europe. *If, then, we accept his conclusions, the occurrence in the same bed of the species Physa (Bullinus) prinsepii, Paludina normalis and the plants Chara malcolmsonii and C. elliptica, pointed out by Hislop (Q.J.G.S., XVI, p. 165, 1860) obviously discredit any idea of conflict between the plant and animal evidence. Had* we found *Chara* or *Nipadites* or a profusion of palm-wood in beds interstratified with the *Cardita beaumonti* beds, there would be evidence of conflict between the plant and animal evidence, but as far as I know, no such record has been found.

It is true, W. T. Blanford remarks that

> 'there are some strong resemblances between some of the fossils of the Rajahmundry intertrappeans and those of the Cretaceous beds of Trichinopoly.' (*Mem. Geol. Surv. Ind., VI, p. 24 (= 160), 1867*).

But the phrase 'strong resemblances' does not seem convincing to the writer who has not seen any systematic comparisons of species by Blanford, which Hislop has given in detail. The same importance cannot therefore be attached to Blanford's opinion as to Hislop's. Unfortunately when Hislop wrote, the fauna of the Cretaceous of South India had not yet been described (*Blanford, loc. cit. footnote, p. 24*) and Hislop himself has not been able to express an opinion on Blanford's comparisons referred to previously.

The evidence of the two leading animal fossils and of the other fauna, therefore, does not conflict with that of the fossil plants. Indeed, the evidence of one of these, *B. prinsepii* even supports that of the flora, for it is one of the commonest fossils associated with the intertrappean plants of known Tertiary age.

*Geological, not palæontological, arguments mainly responsible for supposed discrepancies:*

*Discordance between the Trap and the Infratrappeans.*—The purely stratigraphical evidence brought forward by W. T. Blanford (*Mem. Geol. Surv. Ind., VI, pt. 1, Chap. 9, p. 51, 1869*) in support of a Cretaceous age for the Deccan trap is that there is no great break between these and the underlying formations. King (*Mem. Geol. Surv. Ind., XVI, p. 52, 1880*) expresses himself in similar terms:

> 'the traps do not appear to be disassociated from the Infratrappean beds ..... to such an extent of unconformity as the supposedly Upper Eocene age of the intertrappean beds would require.'

While it may be true that the discordance in dip between the two formations is not great, in the face of the plant and animal fossil evidence it can hardly be suggested that the traps are Cretaceous. It may well prove or, at least, lead us to suspect that the age of the Bagh beds is probably younger than we are accustomed to assign to them. Indeed certain fossil specimens from the Bagh beds, kindly given to me for identification by Mr. P. N. Mukherji, do indicate a higher horizon for them. Amongst these are *Protocardium pondicherriense* D'Orb. *Cardium (Trachycardium) incomptum* (Sow.), *Macrocallista sculpturata* (Stoliczka) and *Turritella (Zaria) multistriata*, which are characteristic of the Upper Cretaceous of Southern India. On their evidence the Bagh beds may range well into the Upper

Cretaceous instead of being referred only to the lower part of the Upper Cretaceous, as thought hitherto. In further support of this I may mention that von Huene and Matley assign an Upper Cretaceous age to the Lametas (fossiliferous sedimentary type), which are supposed to be the terrestrial equivalent of the Bagh beds.

*In this way it has been possible to reconcile the absence of a major discordance with the fossil evidence and thus, at the same time, the supposed gulf between the plant and animal evidence is bridged.*

In passing I may mention a fact of great importance, namely, that the Bagh species just referred to are characteristic of the South Indian Cretaceous. It may therefore well be that the land mass which is supposed to have separated the South Indian Cretaceous sea from the Bagh sea was not a permanent feature during the Cretaceous period, and that it was submerged during periods of marine transgressions. As more fossil evidence accumulates, greater affinity between the faunas of the two regions will, in my opinion, become evident.

The geological argument has been used again by Blanford (*Mem. Geol. Surv. Ind., VI, p. 22* (= *158*) *1867*) in the case of the traps at Surat. He states:

> 'the lower eocene beds of Surat rest quite unconformably upon the traps, and there is clear evidence of an enormous amount of denudation of the latter both before and during the deposition of the Nummulitic sea.'

It is apparent that this argument cannot be treated as establishing the Cretaceous age of the main trap. It only proves that the trap at Surat is pre-nummulitic, but it does not prove that the whole of the Deccan trap is likewise pre-nummulitic.

In the case of the intertrappeans of Rajahmundry Messrs. S. R. N. Rao and K. S. Rao (*Rec. Geol. Surv. Ind., 71, Pt. 4, p. 391, 1937*) find that

> 'Typical cretaceous forms like *Pseudotextularia*, *Gumbelina* and *Globigerina cretacea* are either very rare or altogether absent. On the other hand forms like Orbitoideæ and Nummulites typical of the warm seas of the Eocene age are also absent. According to data now available the evidence of the forminifera seems to be in favour of using the name Palæocene.'

Treating the Rajahmundry trap as constituting an independent centre of vulcanicity, and without assuming that they are the youngest and not the oldest traps, the fossil evidence of their intertrappean beds does not in any way conflict with the palæobotanical evidence.

*Direct animal fossil evidence supports plant evidence.*

*Conclusions of Hislop, Smith-Woodward and others.*—From the foregoing one may conclude that wherever the fossil evidence is reliable or sufficient, the plant and animal evidence support each other. The palæontological work of Hislop, Smith-Woodward (*Pal. Ind., N.S., Vol. III, 1908*) and others is confirmed by the palæobotanical work published in recent years, which in itself discredits any idea of discrepancy. Discrepancies have arisen where attempts have been made to draw conclusions from purely geological considerations.

## II. The Gondwana Rocks.

*The evidence of vertebrate and plant fossils.*

*The Maleri stage.*—There is apparently a serious discrepancy between the evidence of plant and animal fossils in regard to the age of the Maleri stage, for the vertebrate fauna consisting of *Parasuchus*, *Hyperodapedon*,

*Belodon*, etc. indicates Triassic affinities, whereas the plant remains, supposed to have been collected from the same horizon, indicate an Upper Gondwana age. But there has always been considerable doubt whether in fact the vertebrate and plant fossils were found in the same horizon.

Professor B. Sahni wrote:—

'It is important to ascertain beyond doubt the source of these plants, for if they were really from the Maleri beds, this fact would constitute the strongest evidence for a post-Triassic age'. (*General Report for 1928, Rec. Geol. Surv. Ind., LXII, p. 28, 1929.*)

Later Dr. C. S. Fox remarked that—

'If we remember that the correct horizon of the plant fossils from Chirakunt and Naogaon in the Jamgaon Valley has not been satisfactorily settled (although King's map suggests a Maleri horizon), it is evidently true that plant fossils have not been found on the same horizon (red clays) as the reptilian remains of Maleri'. (*Mem. Geol. Surv. Ind., LVIII, pp. 155-156,* 1931.)

From the uncertainty attaching to the horizon of the plant fossils it is clear that their evidence should not be treated as creating a discrepancy. I consider that the evidence of the vertebrates is conclusive in the present instance, and that the plants probably come from a higher Upper Gondwana horizon. In any case fossil records concerning which there is obvious doubt should not be regarded as evidence of discrepancy.

*The Upper Gondwanas of the East Coast, etc.*—A much more serious position has arisen in regard to the age of the Upper Gondwanas in view of Dr. Spath's identification of certain cephalopods found in the Upper Gondwanas of the East Coast. These formations which, on the basis of their plant remains, were hitherto assigned to the Jurassic, are now assigned to the Lower Cretaceous on the evidence of the cephalopods.

Dr. Spath has not confined his views as to age to these, but has extended them to include the Gondwana rocks of other areas. He writes:—

'Moreover, there does not seem to be any essential difference between the faunas of the lowest Budavada beds (Rajmahal Group) and those of the Ragavapuram shales or Sripermatur group of the Middle (Kota) series. That is to say the marine bands in these two series of the Upper Gondwanas, whether in the Godavori District or near Madras, are already of Upper Neocomian age and the correlation of the still higher Tripetty and Jabbalpur series with the Umia group of Kachh is thus altogether erroneous'. (*Pal Ind., N.S., Vol. IX, Mem. No. 2, p. 827, 1933*).

The age of the other Upper Gondwana rocks, according to Dr. Spath, must be raised, likewise, to at least Lower Cretaceous. Yet on the basis of the plant fossils these have been assigned to some horizon or other of the Jurassic. Not only that, Dr. Cotter (*Rec. Geol. Surv. Ind., XLVIII, p. 27, 1917*) states—

'The age of the Kota deposits is not in dispute. It is generally admitted that the flora is later than that of the Rajmahal stage, but older than the Jabbalpur. The fish remains of Kota point to an age not earlier than Lias. The marine fossils found together with a Kota flora at Ragavapuram (*Macrocephalites, Trigonia interlævigata*) point to a Lower Oolite age.'

There is thus conflict not only between the recent palæozoological evidence and plant evidence, but also between the palæontological evidence as put forward by Dr. Spath and Dr. Cotter. The only conclusion that can be drawn is that we are either dealing with heterochronous formations

or that some of the determinations must be provisional. The flora of the East Coast Gondwanas is admittedly small, and I do not know how far it can be compared with the Upper Gondwana floras of other areas. Similarly the cephalopods identified by Dr. Spath are either new species or poorly preserved and not easily determinable forms, but I am not using that as an argument against their Cretaceous age. Their probable Cretaceous age had in fact been postulated long ago by Stoliczka from an examination of certain ammonites (*Pal. Ind. Ser. IX, Vol. I, 1875, p. 236; see also Pal. Ind. Ser. II, Vol. I, p. 223, 1880*). Their evidence, however, is directly opposed to the evidence of the *Macrocephalites* and *Trigonia interlævigata* identified by Dr. Cotter which, as already stated, are Jurassic forms.

Recently the writer, during the course of examination of the marine Jurassic of the East Coast Gondwanas, has come across one or two specimens which, as far as their state of preservation permits, must be referred to the genus *Rectithyris* Sahni. In Europe this genus is confined to the Cenomanian and occurs doubtfully also in the Turonian. It is found in the South Indian Cretaceous at the same horizon, viz. Cenomanian, as in Europe. While it is not suggested that the East-coast Gondwanas are so high up in the sequence, the occurrence of the genus *Rectithyris* is significant. The absence of other South Indian Cretaceous types in this area is an anomaly which may probably be explained upon a difference in the horizons of the beds containing the *Rectithyris* in the two areas.

In view of the foregoing I can only say that a thorough revision of the Gondwana floras and of the faunas of their marine bands is called for before we can definitely prove any semblance of conflict between the plant and animal evidence. It is obvious that the Upper Gondwana system is a composite of heterochronous formations, that there are many faunal and palæobotanical gaps in the sequence, and that the main responsibility for the conflict of evidence rests on these breaks, physical and physiological.

The responsibility therefore rests not upon the fossils, plant or animal, but upon the imperfection of the geological or palæontological record or in its interpretation. With greater and more reliable evidence, the gulf that apparently separates plant and animal evidence will be, in the writer's opinion, bridged over.

### III. The Po Series.

*Apparent discrepancy.*—In the case of the Po series again the discrepancy is due not to differences between the evidence of plant and animal fossils, but to two unfortunate circumstances, namely (*a*) an inadvertent mixing up of two fossil collections from different horizons resulting in incorrect correlation, and (*b*) assigning to *Protoretepora ampla* a much more restricted horizon than actually is the case.

The part of the succession in Sipti with which we are immediately concerned is as follows:—

| | | |
|---|---|---|
| Fenestella shales with *Protoretepora ampla* .. | .. | } Po series |
| Thabo stage .. | . .. .. | } Po series |
| Syringothyris Limestone .. | Lower Carboniferous. | |

Although higher Permo-Carboniferous beds have been found, they do not contain *Protoretepora ampla* as in Kashmir, and this has an important bearing on the subject, as we shall see later.

The lower division of the Po series (Thabo stage) contains plant remains, *Rhacopteris ovata*, *Sphenopteris* sp., *Sphenopteridium furcillatum* Ludwig sp., etc. and was provisionally referred by Zeiller (*Mem. Geol. Surv. Ind., XXXVI, p. 47, 1904*) to the Lower Carboniferous. Recently Gothan and B. Sahni (*Rec. Geol. Surv. Ind., 72, Pt. 2, pp. 202-203, 1937*) have confirmed the probable uppermost Lower Carboniferous age of this sub-division, after a further examination of these plant remains.

In reading through literature dealing with the Po series and related formations, an important fact, which has apparently been completely lost

sight of, has emerged. It would appear that a younger age was assigned to the Po series on a palæontological correlation based on data which are manifestly incorrect, being due, as explained below, to an unfortunate mixing up of two faunas from entirely distinct horizons.

To understand this one must follow the complete succession of Palæozoic rocks at Zewan, in Kashmir:

| | |
|---|---|
| Permian .. | Protoretepora ampla beds more Zewan series. |
| Permo-Carboniferous | Gangamopteris beds. |
| Upper Carboniferous | Panjal trap.<br>Agglomeratic Slate. |
| Middle Carboniferous | Fenestella shales with doubtful *Protoretepora*. |
| Lower Carboniferous | Syringothyris limestone. |

The admixture referred to was between the *Protoretepora ampla* fauna (Zewan stage) and the *Fenestella* shales of the Middle Carboniferous. The result was that the *Fenestella* shales of Spiti (*vide supra*) were correlated with the *Protoretepora ampla* beds (Permian) rather than with the true Fenestella shales (Middle Carboniferous), to which they correspond. As a consequence, a higher horizon was assigned to the Po series, including the *Rhacopteris* flora. I quote from Hayden (*Rec. Geol. Surv. Ind., XL, Pt. 3, p. 261, 1910*):—

> 'This correlation was based on a description by Professor Diener of certain fossil supposed to have been collected in beds of the Zewan stage, but Mr. Middlemiss has shown that they were a mixed lot derived partly from his Fenestella shales and partly from the true Zewan stage.'

Diener himself wrote (*Pal. Ind., N.S., Vol. V, Mem. No. 2, p. 106, 1915*):—

> 'The main mass of the Zewan beds, especially the zone of *Protoretepora ampla*, was even correlated by Hayden, directly with the Fenestella series of Spiti. This correlation which was based chiefly on the predominance of European Carboniferous types in Lydekker's collections, falls to the ground since the distinctness of the two faunas in Lydekker's fossil material has been brought to light by the geological researches of C. S. Middlemiss.'

Middlemiss himself correlated the whole of the Po series with the *Fenestella* shales of Kashmir on

> 'lithological, stratigraphical and on palæontological grounds' (*Mem. Geol. Surv. Ind., XL, Pt. 3, p. 225, 1910*),

apparently without taking into account the plant fossils.

Another factor which is responsible for the correlation of the *Fenestella* horizon of Spiti with the *Protoretepora ampla* beds (Permian) of Kashmir is that the former also contains this well known species, although the remaining fauna indicates a Middle Carboniferous age. Indeed doubtful *Protoretepora* occurs in the Fenestella shales proper of Kashmir and may possibly indicate that even in Kashmir *Protoretepora ampla* does not mark a very restricted horizon, but we cannot be sure of this till the doubtful *Protoretepora* has been specifically identified.

The Po series as pointed out by Hayden (*Rec. Geol. Surv. Ind., XL, Pt. 3, p. 262, 1910*) was—

> 'only very cursorily examined by the late Dr. Krafft and myself and may comprise fossiliferous horizons not yet found.'

Indeed the inference is that the *Protoretepora ampla* horizon of Kashmir, corresponding to the Zewan stage, is probably present also in the Spiti area, but has not so far been discovered.

The evidence of the fauna therefore points to one conclusion: that the original correlation was incorrect and that the *Fenestella* shales of Kashmir

correspond to the *Fenestella* shales of Spiti of Middle Carboniferous age, *but not to the whole of the Po series, as suggested by Middlemiss.*

The position then is that beds containing *Rhacopteris* are underlain by the *Syringothyris* limestone of Lower Carboniferous age (*vide supra*) and overlain by the *Fenestella* shales containing a Middle Carboniferous fauna. They must therefore be regarded as passage beds between the Lower and Middle Carboniferous. On the evidence of plants it is stated (*Gothan and B. Sahni, loc. cit., p. 202*) that—

> 'In Europe they would be assigned most probably to the Visé (upper part of the Lower Carboniferous).'

It is obvious that exact correlation between the minor stratigraphical subdivisions in widely separated regions cannot always be possible—even in the case of the marine faunas. In this connection the conflicting faunal evidence of another formation, the Zebingyi beds, is instructive and one may draw attention to it before reverting to a consideration of the *Rhacopteris* flora. In the Zebingyi passage beds of the Shan States we find both *Tentaculites elegans*, which in Europe is of definitely Devonian age, and certain graptolite species which are definitely Silurian. La Touche adopts what he calls the 'graptolite convention', which practically means that whatever the evidence of the other fauna, where Silurian graptolites occur the beds must be of Silurian age. (*Mem. Geol. Surv. Ind., XXXIX, p. 178, 1913.*)

Although the two cases are not altogether parallel, it is possible that the Thabo stage marks a position very similar (excluding the difference in age) to that of the Zebingyi beds, and if the *Rhacopteris* flora is Uppermost Lower Carboniferous in Europe, it could possibly be treated as a passage flora in India. This position practically bridges the gulf between the evidence of plant and animal fossils. It would be of interest to know what the evidence of such occurrences in the intervening regions between India and Europe would indicate, but apparently no such occurrence has been recorded.

Once more we come to the same conclusion, that such discrepancies as appear to exist are due to doubtful identifications (as in the case of the supposed *Physa* (*Bullinus*) *prinsepii* from the Cretaceous rocks of Beluchistan or to lack of adequate or properly collected material (as in the case of the aforementioned mixing of faunas from distinct horizons) or to drawing conclusions from purely stratigraphical data unsupported by fossil evidence, as in the case of the absence of a major discordance between the Bagh beds and the Deccan traps.

I am, therefore, of opinion that where reliable fossil evidence, whether plant or animal, is available, it should be accepted without reserve, and where the evidence is conflicting, a thorough re-examination of the fauna (or flora) is called for. It has been found that where discrepancies occur between the evidence or plant and animal fossils, the fossil data are invariably unreliable.

### *Do faunas and floras evolve at different rates?*

It has been suggested that under certain circumstances plants and marine animals may evolve at different rates—that marine organisms, owing to the uniformity of the environment under which they live, evolve more rapidly than terrestrial plants and that, as a consequence, newer marine types may be associated with older types of floras. While the association of a more modern fauna with one or two older types of plant fossils (or *vice versa*) may be possible on account of inherent tendencies which do not favour change among such persistent types, I do not think that a large scale occurrence of newer and older types of representatives of the two kingdoms has been established. The main thing to remember is that the conditions of preservation in the two great groups are entirely different, and that the apparent discrepâncies may be due to imperfections

of the plant record. It is an admitted fact that if there is such a discrepancy in the case of the East Coast Gondwanas, where Lower Cretaceous marine types appear to be associated with Jurassic plants, the flora and even the fauna of these beds is far from well-known.

The conclusion then is that in all such cases of discrepancies a thorough revision of the faunas and floras is called for.

In the end the suggestion may be ventured that the geological section of the Science Congress would do a useful thing if they would form 'working committees' to take up the investigation of such crucial problems in hand and report on them at their meetings. Without a close collaboration between palæobotanists and palæontologists the presentation of such problems is likely to be one-sided.

4. Dr. T. W. Stanton, Washington.

I fear that my lifelong dependence on invertebrate fossils as the most reliable guide in the stratigraphy and correlation of Mesozoic formations would disqualify me as an unbiased judge of the question involved in the discussion.

No stratigrapher of this day, I believe, will question the statement that the most nearly complete stratigraphic record is found in marine sediments and that in general the succession of marine invertebrate faunas is fairly well determined. Continental sedimentary formations with their land floras, their vertebrate faunas, and their non-marine invertebrates must be interpolated in the marine sedimentary column by observation of the actual stratigraphic succession, where that is possible, and by interpretation of every available bit of structural, stratigraphic, and paleontologic evidence.

The title of the discussion raises the question whether the reported discrepancies between the testimony of plants and animals are real or only based upon erroneous determinations of species or erroneous estimates of their age values. I should say that it is most probable that some of the discrepancies are real. Land plants, terrestrial vertebrates, and marine invertebrates live under very different conditions and vary greatly in their ability to migrate quickly when living conditions change, or to adapt themselves to changing conditions without migrating. Changes that would seriously affect the environment of one of these classes might not greatly alter living conditions for other classes in the same area. It would be remarkable if the chapters in the history of land plants should exactly coincide in their beginnings and their endings with the chapters in the history of marine animals or even of the land animals of the same region.

The evidence seems to indicate that modern types were introduced somewhat earlier among plants than among animals. For this reason, in America at least, boundaries between systems and other major geologic divisions when based on the evidence of fossil plants are often placed somewhat lower than the faunal evidence would indicate. My lamented friend David White in discussing Permian floras (*Pan-Pacific Congress, Australia, Proc.*, 1923 (1924), vol. 2, p. 1038, 1926) speaks of the 'frequently remarked tendency to greater precocity on the part of the flora as compared with the fauna'. On the evidence of the flora he placed the lower boundary of the Permian in the Mid-Continent field several hundred feet lower than it had been drawn by others on faunal evidence.

While it may be true, as I have suggested, that there are inherent divergences in rate of development and other pertinent features that tend to prevent perfect agreement in age determinations based on different classes of fossils, I have no doubt that most of the discrepancies that have led to so much controversy in the past were caused by the lack of sufficient facts on which to base a sound judgment. If fossils are to be used in determining the age of a formation or stratum, the genera and species must, of course, be correctly identified, their stratigraphic range within

the area under discussion and elsewhere must be known, and there must be no doubt that they actually came from the formation or stratum whose age is in question.

The voluminous literature on the Cretaceous and Tertiary sedimentary formation in the Great Plains and Rocky Mountain areas of the United States is filled with discussions and controversies on the age of the plant-bearing and coal-bearing formations there widely distributed. The discussion began nearly 80 years ago when Meek and Hayden announced the discovery of dicotyledonous leaves in the formation now known as the Dakota sandstone. They knew that the formation could not be later than Cretaceous because they had seen a considerable thickness of marine Cretaceous strata overlying it. Drawings of some of the leaves were sent to Prof. Oswald Heer in Zurich for his opinion as to their age. He replied that comparison of the sketches (he did not have the fossils) with European fossil plants led him to believe that they were Tertiary and probably Miocene. Whether the Miocene age of the European standards of comparison was then well established I do not know, though I understand that the 'Arctic Miocene' which later received much attention has since proved to be in large part older than Miocene. The stratigraphic position of the Dakota sandstone was so easily demonstrated that its Cretaceous age was soon universally recognized. According to geologists who are acquainted with the overlying marine formations and their marine invertebrate faunas, the Dakota sandstone is not younger than late Cenomanian, though some paleobotanists think that its flora indicates Turonian.

The Laramie problem dates back about 70 years when Hayden's Geologic and Geographic Survey of the Territories, King's Survey of the Fortieth Parallel, and other exploratory surveys were active in reconnaissance studies of the geology of the western half of the United States. It was found that fields of coal and lignite are distributed over large parts of South Dakota, North Dakota, Montana, Wyoming, Colorado, New Mexico, and Utah and less extensively in Idaho—States with a total area of nearly 800,000 square miles. Additional great areas of the same coal-bearing rocks extend into the provinces of Canada adjacent to North Dakota and Montana.

Distributed over this vast area and through sediments aggregating many thousands of feet in thickness these coal-bearing rocks naturally did not form a stratigraphic unit, but they soon came to be treated practically as such and were known to many as the 'great lignitic series' or the Laramie formation. The early paleobotanists, such as Lesquereux, called them all Eocene, though he recognized slight differences in age in some of the fields. Other geologists acquainted with limited districts in which the evidence of earlier age seemed to them clear insisted that they are all Cretaceous. Neither group was right.

Gradually, as more refined stratigraphic and palæontologic studies, often accompanied by detailed areal geologic mapping, have been extended over a large part of the area it has been demonstrated that some of the coal-bearing rocks in question lie low in the Upper Cretaceous and are of Turonian or possibly even earlier age; that others are intercalated at intervals in the marine Upper Cretaceous column up to its very top as locally developed; that higher in the section the Fort Union formation contains a well-developed somewhat primitive mammalian fauna which the vertebrate paleontologists call Paleocene; that still higher coal-bearing rocks include the *Coryphodon* zone and associated zones with more highly developed mammalian faunas universally recognized as early Eocene; and that non-marine (fresh- and brackish-water) invertebrates, when discreetly used, may often serve as effective guides to stratigraphy and correlation.

In much of the area over which the Laramie was once such an insistent problem the question of the exact location of the Cretaceous-Eocene boundary is now confined to a few hundred feet of sediments, and there is

promise of an early amicable agreement based on a summation of evidence from all possible sources. When faunas and floras now known in the Upper Cretaceous and Eocene of the western interior region of the United States are all fully studied and described and the stratigraphic ranges of the species accurately recorded, North America will have a dependable paleontologic standard for stratigraphic classification and correlation of this part of the geologic column that may prove of world-wide usefulness.

5. PROF. T. D. A. COCKERELL, Boulder (Colorado).

Animals are in general much more complex organisms than plants, and thus they present more definite structures which may be identified in fossils, and usually evolve or change more rapidly than plants. Fossil plants are commonly known by the leaves or stems, the reproductive structures, as the flowers, being less often preserved. Animals are more motile than plants, and frequently the fauna of successive strata differ mainly in the presence of organisms which were actually contemporaneous with both, but had not reached the locality until the later rocks were laid down.

We have in Colorado two formations, the Green River Eocene and the Florissant shales, each containing very many preserved insects. Although there are some plants which seem to be common to both formations, or at least not distinguishable from the vegetative parts preserved, there are, so far as we know, no insects occurring in both. The Florissant beds are assumed to be Miocene and therefore much younger than the Green River. One of the main features of the Green River insect fauna whereby it differs both from that of Florissant, and from that of modern Colorado, is the presence of numerous prettily marked Fulgoroid Homoptera, looking like moths. Now such insects abound today in the Indian region. If the present fauna of India were fossilized and both it and the Green River beds were viewed from a time in the remote future an argument might well be made for the view that they were contemporaneous, though it would be entirely fallacious.

In the Pennsylvanian rocks (Upper Paleozoic) of North America are numerous plants and insects, the latter mostly cockroaches. The plants represent a fairly uniform flora but every insect horizon contains different species. This does not mean that the successive horizons necessarily represent so many successive stages in the evolution of these insects. It is probable that the differences are in large part due to migrations. Whatever the cause, however, the insects are certainly much more delicate horizon-markers than the plants.

One objection to the use of animals for stratigraphy is that the terrestrial species, at least, are not so often preserved, and hence their absence from the rocks does not mean that they did not exist. It is evident from the study of insect fossils that the leading modern genera were present in Eocene times, but frequently they are known by single specimens or wholly absent from collections made at various places and in various horizons. The fauna as a whole must be used in forming judgments, and single species or groups of species may be misleading. At Florissant, the numerous Bombyliid flies are all of extinct genera except two ; but the Asilidæ or robber flies from the same rocks, also numerous, belong to existing genera. There are many contrasts of this sort.

The rapid evolution of the mammals in Tertiary time is exceptional, and here we do have clearly discernible evolutionary sequences, often quite decisive for stratigraphy. But many creatures have become extinct at periods which can be approximately ascertained, and thus this presence is of value in determining that rocks are at least no younger than such and such a date. We can also use for dating purposes the arrival of animals in a new region, as migrants from Asia to America (such as the elephants) or from South America to North America (such as the sloths).

6. PROF. EDWARD W. BERRY, Baltimore.

Historically the standard geological time-table was a gradually built up patchwork of lithologic units or groups of units and usually a long time elapsed before they received a paleontologic basis. The major divisions or periods of time were at first the names of what we now call systems of rocks and geologists were slow to recognize that a system at its type locality always represented a shorter time than was connoted by the period which bore the same name as the system.

Stated another way it was the time breaks in sedimentation which bounded a system at its type locality which in the first instance enabled geologists to recognize it as an entity, but which subsequently occasioned most of our difficulties of correlation, when sediments were discovered in other regions representing the whole or part of the time that was not represented by sediments in the region where the name was first applied.

In addition our accepted scheme of geological chronology has certain handicaps due to the circumstances of birth. Historical or stratigraphical geology may be said to have passed through its infancy and adolescence in western Europe and it is certainly not a new thought to contemporary geologists that if it had grown up on any other continent it would not only have been a very different scheme taxonomically, but would probably have been a better scheme.

Looking back at the really great achievements of the founders of our science and without wishing to detract one iota from their well deserved renown, I ask the rhetorical questions, would anyone today think of going to Wales to study Cambrian history or even to the land of the Silures to get the best notion of Silurian history ? And if the concept of a Carboniferous system had grown up in Russia or the Mississippi Valley would we not have had a much more logical sequence ? Would there even have been a Jurassic system if geology had grown up in the United States ? I mention these things because it seems to me that they inevitably point to what the geology of the Indian empire shows so plainly, namely : that the syntheses of the so-called geological philosophers, with their cycles and epicycles of diastrophism and their rhythmic orogenies, are foredoomed when extended beyond provincial developments in an attempted world-wide application.

It was inevitable from the days of William Smith that the stratigraphic invertebrate paleontology would become the international standard, although most geologists would probably agree to what Lyell phrased so succinctly, that invertebrates were the hour hand, vertebrates the minute hand and plants the second hand of the geological clock. Marine sediments are so much more general in both time and space, are so much more favourable for the preservation of fossils and in general so much less liable to be destroyed by erosion, that it is quite futile to hope for a geological time-table based on other criteria that will be as useful or as usable.

Since, then, it is the succession of marine sediments and their contained faunas that are the basis of stratigraphic taxonomy, it follows that continental sediments which are the chief normal depositories of land animals and land plants will generally occur at the beginning or toward the end of our standard periods, or in the intervals between the marine sedimentation of the epicontinental or shelf seas.

Most of the controversial questions of stratigraphy have their origin in these circumstances. I may mention the Ozarkian, Hercynian, Permian, Rhætic, Wealden and Laramie as intersystemic problems of this sort, and there are innumerable ones of lesser magnitude involving formational boundaries.

It has been my experience that no group of organisms, either animal or plant, however conservative they may be, are without stratigraphic value or are discrepant with other groups. I well remember how useless for chronology Foraminifera were considered a generation ago, as a result of the long range broadly considered and variable forms of the Challenger

monograph. In recent years I imagine that commercial companies have paid more money to students of Foraminifera than to any other palæontologic specialists, whereas the close relatives of the Foraminifera, the Radiolaria, are but little used and are suspect, largely because they are a tool that no one has learned to use with stratigraphic precision. Diatoms are still considered of slight stratigraphic value but are proving to be of great value in the hands of Lohman of the U.S. Geological Survey.

Instances of this sort could be multiplied indefinitely. In the hands of an expert who knows both the words and the music any class of fossils will be found about equally serviceable. The tradition that plant fossils are inferior to animal fossils in precise chronology is based on a variety of circumstances not the least of which was the lack of understanding of some of its most conspicuous practitioners.

Another large factor was the contemptuous attitude of such outstanding systematic botanists of the floral morphology era as Bentham and Hooker. Much of the material for stratigraphic palæobotany and certainly the bulk that is sufficiently frequent in the geological record to be of any chronological service, consists of impressions or inclusions of detached parts, largely foliar. Quite obviously the impression of a sterile fern frond, or a cycad frond or an angiosperm leaf, is not in quite the same category as the shell of a brachiopod or an ammonite, or a skeleton of a reptile or mammal.

What is usually forgotten by critics of palæobotany, and this is especially the case in those horrible examples set forth by critical writers, of the similarity of diversely related modern plants, as if the poor paleobotanist had to choose between a calamite, an equisetum, a frenela, a casuarina and a polygonum, or between the leaves of 100,000 or more species of dicotyledons.

I venture to think that plant parts are quite as precisely recognizable as any other fossils even if it be conceded that they are identifiable with less certainty, and I would maintain that they would serve as handmaidens for stratigraphy about as well if they were numbered and remained unnamed, just as busy micropaleontologists in their commercial work frequently number instead of naming their horizon markers.

I do not mean to imply that the goal of palæobotany or even of stratigraphic palæobotany is on this low plane, and I would expect foliar features in general to be more conservative than most parts of the plant organism, and as having less selective value and hence less liability to change than floral or anatomical features. I may instance the ginkgophytes or cycadophytes as preserving their essential foliar features over eons of time. Certainly the cycadophytes have retained rather stereotyped foliar characters from the Carboniferous down to the present and during that time have shown great changes in stem anatomy and a still greater change in their floral morphology.

Palæobotany still suffers from the systematic optimism of a Heer or an Ettingshausen and from the habit of comparing fossil plants with pictures of fossil plants in the works of the founding fathers. When the palæobotanical riches associated with the late Cretaceous and early Tertiary coals of the western interior of North America commenced to flow into the hands of our American pioneer palæobotanists—Lesquereux, Dawson and Newberry, they identified many of them by the pictures in Heer's monumental work on the flora of the Swiss Miocene (so-called) or Heer's Arctic Miocene (so-called) and considered our so-called lignitic as Miocene. In the same way Lesquereux determined the first plants from the Wilcox group of south-eastern North America, the plants to which I have devoted so many years, as Miocene, although they are really lower Eocene.

The mistakes are not to be charged to the fossil plants, but to their interpreters. Quite early in the history of geologic exploration in our West when the boundary between Cretaceous and Eocene was being bitterly debated, the vertebrate palæontologist Cope advanced the idea that plant chronology was different from vertebrate chronology and that

what might be called the age of flowering plants started in the mid-Cretaceous, whereas the age of mammals started in the Eocene and it was implied that the flowering plants had undergone but slight changes since those far-off mid-Cretaceous days.

It is true that dicotyledonous leaves in some abundance appear in the record toward the close of the Lower Cretaceous and continue to the present, but they are at first associated with a large number of surviving genera that might be called Jurassic types, and many of these do not disappear until the close of the Upper Cretaceous.

In south-eastern North America which is strategically located at the gates of the American tropics, and whose Cretaceous and Tertiary land was a part of that larger segment of eastern North America which had been above the sea since early Carboniferous, there are abundant and well preserved floras throughout the Cretaceous and earlier Tertiary, which I have had the privilege of studying for the past thirty or more years. The uppermost Cretaceous in this region with prolific marine faunas is the Ripley formation which in clay lenses formed in coastal lagoons along the Ripley coast has furnished 135 species of fossil plants in 71 genera, 40 families and 28 orders. It is overlain by marine lower Eocene which is in turn overlain by the transgressing formations of the Wilcox group. The Wilcox flora is an unusually large one with about 550 described species in 182 genera, 83 families and 43 orders. There are 28 genera in the Ripley which are unknown in the Wilcox and if the latter flora is compared with earlier Upper Cretaceous floras of the same region about 40% of the genera known in these earlier floras are extinct before the Eocene.

There are 84 genera represented in this lower Eocene Wilcox flora which have never been found in any Upper Cretaceous flora in this or any other region and the vast majority of these are dicotyledons, and the species are all different.

It would seem that this brief résumé without greater detail justifies the statement that the dawn of the Eocene marks a great modernization of terrestrial floras, and that these floras show quite as marked a contrast when compared with Upper Cretaceous as do the terrestrial vertebrates or the marine invertebrates.

A well documented volume could be written on this subject but sufficient has been said to illustrate my point of view for the purpose of the discussion.

### 7. Prof. W. Gothan, Berlin.

*Die Bedeutung der Paläobotanik als vollwertiges stratigraphisches Hilfsmittel.*

Auf dem Internationalen Botanischen Kongress in Cambridge—England, 1930, habe ich über dieses Thema im allgemeinen gesprochen; der Vortrag ist in der Palaeontologischen Zeitschrift (13, 1931, S. 298) veröffentlicht worden. Der Aufförderung des Prasidenten der Botanischen Sektion des 'Indian Science Congress', zu der Tagung anlässlich des 25. Jubiläums eine diese Frage kurz beleuchtende Mitteilung beizusteueren, leiste ich hiermit Folge. Insbesondere erfülle ich hiermit einen Wunsch von Prof. Sahni, wenn ich den Wert der fossilen Pflanzen als Leitfossilien auch im Verhältnis zu den Angaben der Paläozoologie und Stratigraphie ins rechte Licht rucke und einzelne mir bekannte Fälle aufzeige, bei denen die Paläozoologen oder Stratigraphen und die Paläobotaniker verschiedener Meinung waren, die Paläobotaniker aber Recht behielten, indem sie sich *folgerichtig* auf die von den fossilen Pflanzen gebotenen Daten stützten. Man findet bis heutzutage die Anschauung, dass die auf Grund der fossilen Flora gemachten stratigraphischen Angaben unsicher seien und dass man sich auf sie nicht unbedingt verlassen könne, insbesondere, dass sie gegenüber denen der fossilen Fauna zurückzutreten

hätten. Insbesondere, wenn von Seiten der Paläobotaniker *und* Paläozoologen über dieselbe Schichtenfolge Aussagen vorlägen, verdienten die der Paläozoologen den Vorzug. Das ist nur insofern begründet, als die Mehrzahl der Fossilien überhaupt tierischer Natur ist und daher die Gliederung der geologischen Formationen sich im allgemeinen auf die fossile Fauna stutzen *muss*. Richtig ist weiter, dass eine Erkennung so gering mächtiger Horizonte, wie sie z.B. auf Grund der Ammoniten im Jura ausgebaut worden sind, auf Grund der Pflanzen-fossilien in pflanzenführenden Ablagerungen nicht möglich ist. Denn es handelt sich bei diesen fast immer um terrestrische Ablagerungen, die in gleichen Zeiträumen in grosserer Mächtigkeit abgelagert werden als gleichaltrige marine Schichten. Es gibt jedoch viele Fälle, wo gar keine Fauna—oder keine horizontbestimmende—vorhanden ist, und dann müssen die etwa vorhandenen Pflanzen allein den Ausschlag geben. Selten kann man auch ganz bestimmte, wenig mächtige Schichtenfolgen an einer einzelnen Pflanze erkennen. Dies ist nur in begrenzten Gebieten möglich wo hin und wieder ein derartig beschränktes Vorkommen von Arten konstatiert worden ist, wie z.B. das der *Neuropteris Bogdanoviczi* in der höchsten Randgruppe Oberschlesiens (vergl. *Gothan*, Ob. Schls. Steinkohlenflora I, 1913, S. 211 und *Gropp*, Arb. Inst. Pal., *3*, i, S. 56). Richtig ist nun allerdings, dass die Palaobotaniker manchmal selbst durch Angaben auf Grund ungenauer Kenntnisse der Einzelheiten des Vorkommens der Arten in den betreffenden Regionen vorlaufige und dann sich oft als unrichtig ergebende Angaben gemacht haben. Das sind aber Fehler, die mit dem Grundsatzlichen der Sache nichts zu tun haben.

Gehen wir jetzt zu einigen Beispielen über, die die Richtigkeit paläobotanisch--stratigraphischer Angaben zeigen. Wir können hier gleich bei dem genannten Oberschlesischen Steinkohlenbecken bleiben, das, nachdem *Gothan* das dortige Karbon 1913 paläobotanisch neu gegliedert hatte, bis in die neueste Zeit fortgesetzt Gegenstand sowohl paläobotanischer als paläozoologischer Studien gewesen ist. In unsern Beispiel handelt es sich speziell um die Stellung der obersten Randgruppe, der Schichten unter den mächtigen Sattelflözen, wo sich die jungsten marinen Schichten des Beckens befinden (Porubäer Stufe der Ostrauer Geologen). *Klebelsberg* hatte im Jahre 1912 auf Grund seiner Untersuchung der marinen Fauna die Randgruppe im allgemeinen mit der Magerkohle des Ruhrreviers verglichen. Auch noch später finden wir bei den Kennern der Goniatiten, die ja ähnlich den Ammoniten im Jura in der Karbonstratigraphie eine besondere Rolle spielen, die Ansicht, dass die obere Randgruppe wegen des Auftretens des '*Gastrioceras circumnodosum*' mit dem Finefrauhorizont des Ruhrreviers zu vergleichen sei. Da auf dem ersten Heerlener Kongress 1927 zwischen den Palaobotanikern and Paläozoologen gar keine Einigung moglich war, indem die ersten für tiefes Namur die andern für unteres Westfal A waren, wurde die Diskussion damals aufgehoben. Bei den späteren Untersuchungen hat sich aber herausgestellt, dass die Bestimmung jedes Goniatiten auf Grund einer alten Abbildung falsch war ; die Paläobotaniker haben vollständig Recht behalten, was jetzt von allen Fachgenossen einhellig zugegeben wird. Bei dieser Gelegenheit kann man noch einmal bemerken, was ich früher schon gesagt habe, dass die Schichtenbestimmung auf Grund von palaozoologischen *und* paläobotanischen Befunden *zusammen*, wenn die Verhältnisse selber es zulassen, erfolgen sollte, dass aber bei beiden Forschungswegen dasselbe heraus kommen müsse. Eine Gleichung kann oft auf verschiedenem Wege gelöst werden, das Resultat muss aber das gleiche sein, oder die eine Rechnung ist falsch, und man muss den Fehler suchen.

Ein zweites sehr lehrreiches Beispiel bildet die Beteiligung der Paläobotanik an der Stratigraphie des Harzes und seiner Fortsetzungen, sowie von Teilen des Rheinischen Schiefergebirges, des Kellerwaldes usw. Auf die lange Geschichte der Entwicklung der Harzstratigraphie, an der zahlreiche Forscher von hohem Rang beteiligt sind, kann hier nicht

eingegangen werden, sondern es können nur hier besonders interessierende Punkte herausgehoben werden. Da ist zunächst die sogenannte Tanner Grauwacke des Oberharzes, die nach vielem Hin und Her von den im Anfang des Jahrhunderts massgebenden Geologen wie *Lossen*, *Denckmann*, *Kayser*, *Koch* und *Beushausen* als silurisch angesehen und schliesslich auch von *H. Potonié* in seiner Flora des Silurs und Kulms ' 1901 als silurisch aufgeführt wurde. Er hatte sie ursprünglich und zwar richtig als oberdevonisch angesprochen, was bei ihr als einer echten Cyclostigmen-Flora durchaus richtig war, hatte sich aber von den genannten Geologen uberstimmen und uberzeugen lassen. Später hat er allerdings diese Ansicht wieder zurückgenommen. Durch die neueren Untersuchungen des Harzes besonders von *Schriel* und *Dahlgrün*, mit denen ich die Sache sehr oft besprochen hatte, ist die Sachlage vollständig geandert worden. Das kommt sowohl in dem ' Harzführer ' von *Schriel* und *Dahlgrün* (I. Teil, 1925, S. 135) als auch in den Erläuterungen der neuen geologischen Blätter zum Ausdruck, soweit sie schon erschienen sind. In dem genannten ' Fuhrer ' erscheint die ' Tanner Grauwacke ' noch als Unterkarbon. Die Autoren sind dann aber nach dem Erscheinen des Fuhrer vom oberdevonischen Alter dieser Schichten uberzeugt worden, wie sich aus den Erlauterungen ergibt. Für den Palaobotaniker musste dies bei dem Vorhandensein der Cyclostigmen von vornherein feststehen, wie auch *Nathorst* bald nach Erscheinen der *Potonié*-schen ' Silur-und Kulm Flora ' bemerkt hat. In den Erläuterungen z.B. zu Bl. Zorge (Lief. 282, 1 S. 17 ff.) ist die Tanner Grauwacke als Oberdevon aufgenommen.

Die erste Bresche in das ' Silur ' der älteren Harzgeologen wurde ubrigens nicht im Harz selbst gelegt, sondern bei der Veroffentlichung des geologischen Blattes Schonebeck mit den Quarziten von Gommern im Jahre 1924 (s. Erlauterungen Bl. Schönebeck, S. 11). Dieser Quarzit, der von Denckmann durchaus richtig mit dem Acker-Bruchberg Quarzit des Harzes und dem Kellerwald-Quarzit in Verbindung gebracht wurde, galt wie die anderngenannten Schichten und wie sich auch aus *H. Potonié's* ' Silur-und Kulm-Flora ' ergibt, ebenfalls als silurisch. Auf eine Anfrage des früheren Prasidenten der Preussischen Geologischen Landesanstalt *Beyschlag* uber die Meinung der Paläobotanik vom Alter der Gommerner Quarzite, musste ich die Antwort erteilen, dass diese nur als unterkarbonisch betrachtet werden könnten, und zwar wegen des Vorkommens verschiedener Archaeopteridenblätter und von zweifellosen Stigmaria-resten. Daraufhin wurde auf der geologischen Karte der Quarzit geger die Meinung verschiedener anderer Geologen als unterkarbonisch gekennzeichnet. Damit war aber zugleich die Frage aufgerollt, wie es nun mit dem Acker-Bruchberg und Ilsenburger Quarzit im Harz selbst und mit dem genannten Kellerwald-Quarzit bei Wildungen sei, die ebenfalls als silurisch galten. Da vom Acker-Bruchberg ebenfalls eindeutige Stigmariareste vorliegen, so war für den Paläobotaniker die Antwort von vornherein gegeben, was ja auch bei der bereits erkannten Gleichaltrigkeit mit dem Gommerner Quarzit folgerichtig war, nämlich dass auch dieser unterkarbonisch sei. Im dem bereits genannten ' Fuhrer ' (I. S. 124) ist die Frage noch offen gelassen und die Meinung ausgesprochen, dass sich Gesteine verschiedenen Alters in den Quarziten des Acker-Bruchbergs befinden könnten. Auf der geologischen Ubersichtskarte des Harzes (1 : 200,000) sind die Schichten als ' oberdevonisch ' bezeichnet. Nach dem paläobotanischen Befund, sind sie wenigstens z.T. als unterkarbonisch wie der Gommerner Quarzit anzusehen. In den sicher gleichaltrigen Kellerwald-Quarziten hat dann später *H. Schmidt*-Göttingen eine *unterkarbonische* Fauna nachgewiesen, wodurch die Frage im Sinne der Paläobotaniker erledigt ist.

Nur wer weiss, was für Kämpfe die Harzgeologie im Laufe der Zeit gekostet hat und wie z.B. auch ich mich mit den Harzgeologen herumstreiten musste, die ursprünglich nicht zu uberzeugen waren, kann die Schwierigkeit der Stellung eines Paläobotanikers besonders gegenüber der früheren ' Silurfront ' angeseheuer Geologen verstehen. Die Beteiligung

der Paläobotanik hierbei ist in der Literatur relativ wenig in die Erscheinung getreten (vergl. u.a. *Schriel-Gothan*, Jb. Preuss. Geologische Landesanstalt, *48*, S. 302 ff), und deswegen ist vielleicht diese kurze historische Darstellung von besonderm Interesse.

Weitere Beispiele in dieser Frage bieten das Ruhrrevier und seine nördlichen Anhängsel, (Ibbenbüren und Piesberg) sowie seine westlichen Fortsetzungen, das Erkelenzer und Aachener Karbon. Das Ruhrrevier ist ein klassisches Beispiel für die Gültigkeit der Hilt-schen Regel, die auch im wesentlichen auf Grund der dortigen Verhältnisse aufgestellt worden ist. Sie besagt, dass normaler Weise in Steinkohlenablagerungen der Gasgehalt, d.h. der Gehalt an flüchtigen Bestandteilen der Kohlenflöze, von oben nach unten allmählich abnimmt. In keinem andern Becken kann mit solcher Regelmässigkeit eine Abnahme des Gasgehalts der Kohlen von oben nach unten nachgewiesen werden, von Kohlen mit 40% Gas bis zu Halbanthraziten mit 10% Gas und noch weniger in den Kohlenspuren des Flözleeren. Daraus ergab sich für die Geologen eine ebenso bequeme wie billige Methode die Schichten im Ruhrbecken oder dessen nördlicher Fortsetzung, in dem Münsterschen Kreidebecken, in Bohrungen zu horizontieren, indem einfach der Gasgehalt der Flöze festgestellt wurde und darnach die Horizonte, die ja im Ruhrrevier sogar nach der Kohlenart benannt werden, sodass hier eine blosse Kohlenqualitätsbezeichnung zu einem stratigraphischen Begriff geworden ist. Bei den Versuchen jedoch, dieselbe Methode in den losgelösten Anhängseln des Ruhrbeckens, namentlich bei Ibbenburen und dem Piesberg sowie auch beim Erkelenzer Karbon anzuwenden, ergaben sich vollkommene Fehlschlusse. Die mageren Kohlen von Ibbenbüren und die Anthrazite des Piesbergs galten bei den älteren Geologen als womöglich noch älter als die Magerkohlen des Ruhrbezirks. Die Paläobotanik ist es gewesen, die mit diesen Irrtümern aufgeräumt hat; Cremer hat schon (Glückauf 1895, S. 129) die Sachlage richtig erkannt. Der richtige Anschluss der jetzt isolierten karbonischen Horste oder Aufpressungen von Piesberg-Ibbenburen ist erst von *Haack* und *Gothan* viel später nachgewiesen worden (Glückauf 1924, No. 26).

Der sogenannte Horst von Muhl-Wassenberg im Erkelenzer Karbon war ebenfalls auf Grund der Magerkeit der Kohlen viel zu tief im Schichtenverband angesetzt worden (*Krusch* und *Wunstorf*, Glückauf 1907, No. 15). Die Palaobotaniker (*Jongmans*, *Gothan*) haben die Irrtümlichkeit dieser Auffassungen auf Grund der Flora nachgewiesen. Übrigens vertraten fur das Aachener Karbon manche Bergleute noch ziemlich spät die Anschauung, dass die mageren Kohlen des Engfaltungsbezirks im Wurmbecken der tieferen Magerkohle des Ruhrbeckens entsprächen. Hier hat ebenfalls die Flora (zusammen mit andern Umständen) den richtigen Weg gewiesen.

Wie primitiv manchmal die Auffassung mancher Geologen im Anfang des Jahrhunderts über die stratigraphischen Möglichkeiten der fossilen Flora war, sei an einem Beispiel einer jurassischen Kohle aus China gezeigt, das ich selbst erlebt habe. Aus dem Kohlenvorkommen von Pingshiang (verg. z.B. *Sze*, Mem. Nat. Res. Inst. Geology, XII, 1931, Nanking) erhielten wir um das Jahr 1904 durch den Ingenieur *Lutz* eine Sendung von Pflanzen und Tierfossilien. Unter den letzten befanden sich auch Süss-oder Brackwasserzweichaler vom Habitus der *Carbonicola*-Arten, deren allgemeiner Charakter sich ja in den postkarbonischen Formationen, auch im Jura, Wealden (Cyrenen) nicht gerade erheblich verändert hat. Das kohlige Aussehen dieser Muscheln und die Ähnlichkeit mit den *Carbonicola*-Arten des Karbons brachte einige hiesige Geologen auf die Idee, es handle sich um karbonische Kohlen, und ich entsinne mich noch sehr genau, wie *H. Potonié* und ich damals Mühe hatten, die betreffenden Herren zu uberzeugen, dass das Vorkommen von *Dictyophyllum*, von grossblättrigen *Cladophlebis*—Arten wichtiger sei, als die nichts oder wenig besagenden 'Anthracosien' wie diese Muscheln damals meist genannt wurden. Dabei kam aber vielleicht bei den Geologen dazu, dass sie die Kohlen gern als karbonisch abgestempelt hatten, weil sie meinten,

dass damit über die bessere Qualität etwas ausgesagt sei. Ähnlich war es mit gewissen Jurakohlen von Schantung, deren jurassisches Alter gewissermassen verheimlicht wurde. Dass aber Jurakohlen und auch tertiäre Kohlen so gut sein können wie karbonische, ist ja jetzt wohl allgemein bekannt.

Ein weiteres Beispiel für unsere Frage bietet die Geschichte der Stratigraphie des grossen Kohlenbeckens von Kuznezk am Altai. Während wenigstens für den oberen und wichtigsten Schichtenteil der paläeozoischen Kuznezker Kohlenformation besonders auf Grund des Vorkommens von Callipteriden die Paläobotaniker sich für permisches Alter aussprechen mussten, konnten sich die Paläozoologen mit diesem Standpunkt nicht befreunden und setzten die Schichten tiefer ins Karbon auf Grund der Fauna. Es ist mir nicht bekannt, wie sich augenblicklich die Paläozoologen dazu einstellen. Die Frage dürfte nunmehr endgültig zu Gunsten der Paläobotanik entschieden sein durch den Vergleich mit dem von *Bexell* festgestellten Profilen in Nanschan-Gebiet (Prov. Kansu, nordöstliches Tibet). Hier wurde nach der vorläufigen Veröffentlichung von *Bexell* und *Halle* festgestellt, dass die Schichten mit Angaraflora (Kuznezker Flora) und zahlreichen Callipteriden über Schichten mit typischer *Gigantopteris* flora, wie sie im östlichen Asien bekannt ist, lagern. Diese ist von *Halle* schon früher und ganz sicher mit Recht als permisch beurteilt worden, was noch später und jetzt vor kurzem durch *Callipteris*-Funde in Schansi bestätigt wurde. Danach dürften die Shihhotze-Schichten des Profils von Schansi dem unteren Perm (Rotliegenden) angehören ; die betreffenden Angaraschichten von Nanschan können aber unmöglich als karbonisch gelten, sondern müssen jungeren Schichten des Perm angehören und demgemäss die betreffenden Schichtenpakete von Kuznezk auch (Zone II von *Neuburg*).

So darf man auch dem Ergebnis der Untersuchung der Spiti-Pflanzen aus den Po-Schichten des Himalaya, die *Gothan* und *Sahni* als unterkarbonisch bestimmten, durchaus Glauben schenken, zumal eigentliche Gegengründe paläozoologischer Art nicht vorliegen. Ein mittelkarbonisches Alter, d.h. also etwa Westfal im Sinne der Heerlener Beschlüsse, wie es bisher mit Vorliebe angenommen wurde, ist abzulehen.

Dafür, dass auch im Mesozoikum manchmal unter entsprechenden Umständen Florenfolgen an den verschiedensten Stellen der Erde sich stratigraphisch sehr brauchbar zeigen, kann die Gleichartigkeit der Folge der Rhät-und Liasflora in Schonen und Ostgronland genannt werden ; hier sind besonders die Arbeiten von *Harris* zu nennen. Hier wie dort lässt sich übereinander unschwer eine rhätische und unterliassische Stufe unterscheiden, die tiefere unter anderm durch *Lepidopteris Ottonis* charakterisiert. *Harris* unterscheidet eine rhätische *Lepidopteris*- und eine liassische *Thaumatoperis*-Stufe, die sich in ganz ähnlicher Weise in Schonen wiederfinden. 1914 wurden von Gothan in Franken die betreffenden Schichten ganz ähnlich gefunden und unterschieden und daraufhin die sogenannte ‘ Rhätflora ’ von Franken als liassich bezeichnet und ferner die *Lepidopteris*-Schichten von Koburg und Oberschlesien als rhätisch angesprochen. Weitere Charakerpflanzen mögen in den Arbeiten von *Nathorst, Harris* und *Gothan* nachgelesen werden (*Nathorst*, Floran vid Bjuf. Sver. Geol. Undersökn. C, No. 27, 33, 85, 1878–86 ; *Gothan* Abh. Nat. Ges. Nürnberg, 19, 1914 ; *Harris*, Rhaetic Floras, Biolog. Reviews, 6, No. 2, s. 133, 1931 ; *Gothan*, Ztschr. D. Geol. Ges. 87, 1935, No. 10).

Auch im Tertiär Mitteldeutschlands spielt die Paläobotanik mehr und mehr eine ausschlaggebende Rolle, da vielfach andere genügende Indices fehlen. Als Beispiel sei hier die Dürener Braunkohle genannt (Rheinl.). Schon vor mehr als 10 Jahren habe ich mit *Wunstorf* eine Gleichaltrigkeit mit der Ville-Kohle erkannt und versucht, unsere Meinung für die geolgische Kartierung durchzudrücken. Dies gelang uns aber damals nicht ; erst jetzt ist in Folge der Untersuchungen von anderer Seite die richtige Erkenntnis zum Durchbruch gekommen und die ‘ Kieseloolith-Schichten ’, auf Grund. deren u.a. die betreffenden Kohlen

als Pliozän angesprochen worden, haben jetzt zum Teil ihre Bedeutung eingebüsst, und die Paläobotanik ist in ihr stratigraphisches Recht getreten. Man könnte noch mehr über ihre Rolle in der Einordnung der Braunkohlen des Mitteldeutschen Tertiärs sagen. Es mag aber dabei sein Bewenden haben, da der Zweck unserer Darlegungen, die *Wichtigkeit und Richtigkeit der Aussagen der fossilen Flora in stratigraphischen Hinsicht auch gegenüber etwa anderslautenden paläozoologischen darzutun*, erreicht ist.

8. DR. ALEX. L. DU TOIT, Johannesburg.

*Homotaxis and continental drift.*

The apparent discrepancies in the dating of formations by means of their respective marine and terrestrial fossils can be ascribed to :—

(1) Uncertainties pertaining to the geological system-boundaries either locally or regionally, whereby correlation-errors are introduced, e.g. the limit between Carboniferous and Permian.

(2) Inaccuracies in fossil identifications, the more frequent in the case of fragmentary plant remains.

(3) Presence of persistent forms or 'hold-overs'.

(4) Divergences in the evolutionary trends in sea and on land.

(5) Evolutionary changes during migration along extended paths, whereby, as forcefully pointed out by Huxley in 1862, widely parted faunas could become 'homotaxial' instead of synchronous, correspondences in stratal successions not necessarily implying contemporaneity in deposition. Considering the enormous extent of the earth's surface, absolute synchronism throughout geological history would seem distinctly improbable.

(6) Convergences in faunal or floral types, due basically to similarities in their particular environments. For example, the likeness between the Permian floras of Angaraland and Gondwanaland, which were both temperate or cold climate assemblages, contrast with those of the rest of the world, which generally had a warm habitat.

(7) Climatic, oceanographic, orogenic or other influences that have affected in different degrees or senses the life of the seas and lands and impressed themselves differently on the marine and terrestrial biota. Such changes are currently presumed to have been more marked or uneven upon the lands, where the life was subject to extreme variations in temperature, humidity, etc.

(8) A further and vital factor, which has not received attention so far, is, however, *Continental Drift.* The author has elsewhere set forth the numerous arguments favouring a creeping of the condensed land-masses of 'Laurasia' and 'Gondwana' over a revolving core, on the whole southwards during the Devonian and Carboniferous, when the motion became reversed, with some anti-clockwise rotation as well. Such resulted in the progressive shift across the face of the Earth of the main climatic zones, with consequent changes of biological environment and therefore of evolutionary influences, especially upon the lands and particularly in regard to their vegetation, which had not the mobility of the animals.

As an extreme case an area could well within an epoch have changed from say a sub-tropical through a dry to a wet-temperate environment, whereas in an adjoining one the reverse might have occurred. The coals of the Palæozoic were accumulated under either warm-moist or cold-moist conditions, and respectively mark out the former equatorial or polar sides of the two high-pressure low-rainfall girdles, which in turn tend to be characterized by continental 'red beds' phases. The frequent association of such red strata with the coal-bearing facies finds its explanation in fluctuation or migration of the northern and southern limits of those low-rainfall girdles.

The progress of such a climatic 'wave' should tend obviously to speed up, or contrariwise to retard, the normal evolutionary processes and thereby lead to the abrupt appearance of new forms and/or to the preservation of old ones, as well instanced in the Triassic flora of South Africa.

(9) Discordances in the datings derived from the marine and terrestrial remains are hence likely, though the maximum lack in agreement may perhaps nowhere have exceeded a fraction of an epoch-- say a few million years or so.

(10) Although the marine fossils would generally constitute a fairly consistent geological clock, palæobotanists should have no hesitation in stressing the plant evidence should the latter be weighty, although at variance with the conclusions currently drawn from the associated marine faunas. Thus for certain strata commonly recorded as Lower Permian from their fauna, their flora is wholly indicative of a late Carboniferous age, such apparent discrepancy being largely due to the upper limit of the Carboniferous having consistently been drawn at a lower level than is done by the Russian geologists for the type region of the Permian.

9. PROF. H. C. SZE, Nanking.

*Die Meinungsverschiedenheit zwischen Palaeozoologen und Palaeobotaniker ueber die Altersfrage.*

Die Meinungsverschiedenheit zwischen Palaezoologen und Palaeobotaniker uber die Altersfrage ist bei uns genau dasselbe. So z.B. uber das Alter der *Gigantopteris*-Flora ist die Meinung zwischen Geologen immer noch nicht einig und wird vielleicht niemals einige sein. Halle, White, Gothan und Sze hielten es für Unterperm ; T K. Huang hat aber auf Grund der Fauna und stratigraphischen Verhältnisse in Sudwest-China es bereits zum 'Upper Permian' umzudeuten versucht. Die Japanische autoren (Yabe u. a.) haben immer noch schlechtweg die *Gigantopteris*-Flora als Permo-Trias betrachtet. In einer neuen Veröffentlichung, stellen Ting und Grabau die Shihhotze Serie in Shansi zum 'Middle Permian' (Report of XVI Intern. Geol. Congr. 1933). Man muss also darüber noch mehr Arbeiten um diese Frage klar zu machen.

10. MR. H. CROOKSHANK, Calcutta.

*The Ammonites of the Madras East Coast and the Age of the Upper Gondwanas.*

Dr. L. F. Spath's description of Upper Neocomian ammonites in the Gondwana rocks of the East coast of Madras is of the utmost importance to Indian geology. If his somewhat tentative identifications are accepted it raises the age of these rocks by a whole geological division.

One point about which he seems to be misinformed is that this determination will raise the age of the Rajmahal plant beds throughout India. The rocks in which the fossil ammonites have been found are the Ragavapuram shales, the Sripermatur group, the Budavada sandstone and the Vamevaram shales. Spath reports that the fauna of all these rocks is identical. Feistmantel (*Pal. Ind. Sr. II, IX and XII, I, pt. 4, 191–224*) already regarded their floras as indistinguishable one from another. He describes them as being midway between the Rajmahal flora and the Jabbalpur one. The only true Rajmahal floras from the East Coast of India occur in the Golapilly beds and the Athgarh sandstones. King (*Mem., XVI*) expressly states that the Golapilly beds underlie the Ragavapuram shales with their ammonite fauna. He could not be

certain that they were separated by an unconformity, but he believed they were.

Spath's identification raises the age of the plant beds in the East Coast Gondwanas from middle Jurassic to lower Cretaceous ( ? Barremian). Arguing from the floras found in Kota and Jabbalpur he concluded that these beds as well as the somewhat older Rajmahals should be raised from lower and middle Jurassic to lower Cretaceous also. I propose to show that the correctness of this deduction is very questionable.

The modern tendency in palæobotany is to greatly reduce the number of species based on leaf impressions alone. Thus the following plants regarded as distinct by Feistmantel are regarded as varieties of the same species by Seward:—

*Ptilophyllum acutifolium,*
*Ptilophyllum cutchense,*
*Otozamites hislopi,*
*Otozamites gracilis,*
*Otozamites angustatum,*
and *Otozamites distans.*

Any of these would now be described as *Ptilophyllum acutifolium.* This wholesale rejection of species has tended to greatly reduce the differences between the various Indian Upper Gondwana floras.

Work in the Satpura Gondwana basin (*Crookshank, Mem. LXVI, pt. 2*) has recently brought to light 12 new Jabbalpur species. Nine of these were formerly regarded as typical of the Rajmahal flora, and two of the Umia.

In spite of these discoveries the Rajmahal flora still remains fairly distinct on account of the abundance of large cycadaceous fronds in it, and of the presence of such ancient forms as *Danæopsis* and *Thinnfeldia.*

The remaining Upper Gondwana floras are brought much closer to one another than heretofore, so that it is doubtful if the distinctions between them have more than a local significance due to their wide geographical distribution. If anything the flora of Umia seems to be younger than those of Jabbalpur, Kota, and the upper Gondwana beds of the East Coast of Madras, for it is deficient in the more ancient plant genera such as *Dictyozamites, Pterophyllum, Nilssonia,* and *Tæniopteris.* Spath's statement that 'plant-beds comparable to those formed in Kachh in Portlandian times (Zamia shales of Nurrha) and in the upper Tithonian and lowest Neocomian do not seem to be known from Peninsular India' seems designed to explain the reason why there is such a very large difference in age between the upper Gondwana beds of Kachh and those of the Madras East Coast. The statement does not, however, bear investigation. The *Zamia* of the Nurrha shales is a variety of *Ptilophyllum acutifolium.* This leaf impression is certainly the commonest of all those found in the upper Gondwana rocks of Peninsular India. It is often found in great profusion among the carbonaceous shales of the Jabbalpur series, and in some cases it is the only leaf impression present.

As far as the fossil floras are concerned there is little difference between those of Kachh, Jabbalpur, Kota, and the Madras East Coast. The ammonites in Kachh show that the Umia flora is upper Jurassic, those identified from the Madras East Coast that the flora there is lower Cretaceous. The only reasonable deduction is that the land flora in India changed very little over a prolonged period in the upper Jurassic and the lower Cretaceous. Such a conclusion would not be particularly remarkable, for similar floras persisted with little change from lower Jurassic to the end of the Wealden in Europe and other areas. It seems to me quite unfair to say that the Jabbalpur and Kota floras are Cretaceous because those on the East Coast of Madras are. They might equally easily be Jurassic, as is the Kachh flora.

But there is other evidence which tends to show that the Jabbalpurs and Kotas are at least as old as the Kachh plant beds, and perhaps older,

Evidence from fossil leaf impressions is never very satisfactory, but such as it is it tends to place the Jabbalpurs and Kotas in the lower half of the Jurassic. All the Jabbalpur species range through wide periods in the Mesozoic era, but, as one genus, *Dictyozamites*, is especially characteristic of the mid-Jurassic, and as others, notably *Pterophyllum*, *Nilssonia*, and *Tæniopteris*, are rarely found higher than this, it is probable that the Jabbalpur rocks are at least as old as mid-Jurassic. As the Kachh plants seem to be slightly younger than the Jabbalpur ones, and as there is often an apparent difference in age between marine and terrestrial forms this position would be quite in accordance with the ammonite evidence from Kachh.

In support of the evidence from the fossil floras there is field evidence from at least three areas to show that the Jabalpur and Kota beds overlie quite conformably beds in which Triassic and Rhætic Reptilia and Amphibia are found, and from another area which shows that fresh water fish remains of Liassic age occur in beds either immediately below or interbedded with the plant remains.

The Kota-Maleri area is by far the most important of these. Some of the best known geologists of the Geological Survey of India have visited or mapped the rocks of this area. They all agree that there is only one rock formation present. At its base it is rich in coloured clays and poor in sandstones. As one passes upwards through the succession the clays become rarer and the sandstones commoner till at the top of the formation it is mainly sandstone. About the middle of this formation occur three limestone bands.

The plant beds with Jabalpur fossils are commonest at the top of the formation, but they extend down as far as the limestone bands. Opinions are divided as to whether they are interbedded with them or not.

The limestone bands contain a rich fish fauna of liassic affinity (*Egerton and Miall. Pal. Ind. Ser. IV, Vol. I*). Reptilian and Amphibian remains are found most abundantly at the base of the formation, but they extend upwards as far as the limestone bands and are locally interbedded with them. All are agreed on this point. The age of the reptilians has been determined as uppermost Trias or Rhætic. I wish to emphasize here that several of the most famous of Indian Geologists (*Lydekker, Pal. Ind. Ser. IV, Vol. I; King, Hughes, Blanford*) have failed to find any signs of a break in sedimentation in this formation, nor is the succession of plant and animal forms any reason for suspecting the presence of one.

In the Jabbalpurs of the Satpura Gondwana basin there is a large fossil flora. The Jabbalpurs pass downwards without any sign of unconformity into the Denwas a formation built up of thick beds of red clay and white sandstone. In the red clays some hundreds of feet below the plant beds remains of *Mastodonsaurus*, a late triassic reptilian, have been found.

The situation at Tiki where a fauna almost identical to the Maleri one has been discovered, is very similar. The connection of the Tiki beds with the overlying Jabbalpurs is, however, not so clear as it is in the Satpuras, and at Maleri.

Thus the field evidence strongly favours the view that the Jabbalpurs and Kotas are closely connected with the underlying bone beds. If it is desired to move the Jabbalpurs bodily up to a lower Cretaceous horizon, it becomes almost necessary to move the Maleris and Denwas up to the top of the Jurassic or the base of the Cretaceous. To move the age of reptilians, amphibians, and fishes upwards by a whole geological epoch seems to me to be a ruthless act.

Having regard to the field and fossil evidence it would be much wiser to leave the base of the Jabbalpur series in its present mid-Jurassic position, that is a little older than the plant beds of Umia with their interbedded ammonites of Portlandian age. To correlate the base of the Jabbalpur with the equally distant plant beds of the Madras East Coast seems to me quite unnecessary.

The period during which Jabbalpur sedimentation continued is quite uncertain. The beds are strung out in a long line from Rewa to western Hoshangabad, a distance of several hundred miles. They are not quite continuous but sufficiently nearly so to be sure that they have been deposited in two or three basins lying along the southern margin of the present Narbada valley. The characteristic and extremely uniform lithology of the group suggests that the conditions of deposition were everywhere the same. There is no evidence, however, that the different basins are of exactly the same age. There is in fact a little plant evidence to show that they were not. Thus at Jabbalpur the fossil plants are mainly conifers and ferns of relatively modern appearance, while in the Narsinghpur district (*Crookshank, Mem. LXVI, Pt. 2*), some 50 miles further west, large cycadaceous fronds of archaic aspect abound. Although the Jabbalpur rocks are never very thick, it may be that they have been slowly deposited over a long period of time during which land conditions remained very stable. They may even represent the period from mid-Jurassic to mid-Cretaceous. That they could not have continued much later is fairly certain, for the next flora found in Peninsular India, that associated with the earliest flows of the Deccan Trap, is entirely different. This flora is considered to be earliest Eocene. As the palms are represented in it by numerous species it is certain that its roots must extend far down into the Cretaceous. There is, however, not a trace of a palm in any of the upper Gondwana rocks.

The occurrence in Madras of lower Cretaceous ammonites in beds containing a flora characteristic of the lower or middle Jurassic is somewhat of a mystery. It is a well-known fact that mesozoic floras cover an enormous time range. From the earliest Jurassic to the end of the Wealden period there is no very marked change. It is quite possible that a Jurassic flora could have lingered along the Madras coast well into the Neocomian period, but it is remarkable that such relatively ancient genera as *Dictyozamites*, *Pterophyllum*, *Nilssonia*, and *Tæniopteris* should be so well represented there; so strange is this that it must inevitably cast doubt on Spath's conclusion, the more so as this is based almost entirely on generic rather than specific determinations, and the material available was badly preserved.

Fortunately there is some chance of checking the ammonite evidence. Associated with these fossils is a large marine fauna, mainly lamellibranch. So far as I can ascertain, these have never been thoroughly investigated. Two marine fossils from the Tripetty beds immediately overlying the ammonites in the Godaveri delta were identified by Stoliczka as *Trigonia ventricosa* and *Trigonia smeei*; forms which are extremely common in the Umia (Portlandian to early Neocomian) of Kachh (*King, Mem. XVI*). This directly contradicts the evidence of the ammonites, and suggests a Jurassic age for the plant beds here as elsewhere.

11. Dr. R. W. Chaney, Berkeley (California).

Many discrepancies in the stratigraphic testimony offered by terrestrial plants and animals appear to result from factors involved in geographic distribution. This is particularly true in the case of Cenozoic rocks, whose stratigraphic units are finely differentiated, and in which the details of faunal and floral development are relatively well known. An example may be mentioned which was involved in a recent study in western North America.

In the Ogallala formation, laid down during later Tertiary time on the eastern flanks of the Rocky Mountains, a mammalian fauna including horses and a beaver has been referred to the Lower Pliocene. At this same locality in north-eastern Oklahoma, there has been collected a flora made up of well-preserved leaves of angiosperms. All its genera and more than half the species have been previously recorded in the Miocene of Colorado and Oregon. If it be assumed that during the

Upper Miocene the vegetation was uniform from Oregon to Oklahoma, there can be no conclusion other than that the evidence of the plants is not consistent with that of the animals.

Well-marked differences may be observed between the modern vegetation of Oregon and of Oklahoma. Our knowledge of the Tertiary history of western America gives us little basis for supposing that such differences were any less apparent during Miocene and Pliocene time. The attitude of the orthodox stratigrapher has served to obscure or completely prevent the recognition of local differences in plant life; but there can be no rational basis for the assumption of a 'cosmopolitan' flora over a range of nine degrees of latitude, and across a north-south range of mountains. The fact that a fossil flora in Oklahoma has genera and species in common with one in Oregon may in no accurate sense be interpreted as indicating that the deposits containing them are of the same age. In the case of land plants, which migrate relatively slowly, such a resemblance is probably an indication of a *difference* in age.

Studies in progress over the past two decades are yielding a large body of evidence in support of the theory that the more characteristic elements of Tertiary vegetation have migrated southward down both sides of the Pacific from a northern source. This migration is considered to reflect a trend towards a colder and drier climate, resulting from gradual emergence during the Tertiary, and no doubt from other causes. Plants which characterize the Miocene of Oregon are known to have been present in Alaska during the Eocene. It is reasonable to suppose that these same plants should have occupied a position still further south during the Pliocene, as a result of a continued response to climatic change. The presence in the Pliocene of Oklahoma of vegetational elements which characterize the Miocene a thousand miles to the north-west is therefore to be expected. Greater mobility of mammals appears to have made possible their rapid migration over wide areas during the Pliocene. A closer faunal uniformity may therefore be expected than is the case with plants. It is possible that with increased knowledge of their geographic and stratigraphic occurrence, the idea that animals were contemporaneous over extensive areas of sea or land may also have to be modified. In any case the abandonment of the concept of cosmopolitan floras in no way affects their value as stratigraphic indicators, if their latitudinal relations are considered and if their direction of migration is known.

A large number of apparent inconsistencies between the age evidence of plants and animals have resulted from inaccurate recording of their stratigraphic position. The question of the boundary between the Mesozoic and Cenozoic rocks in the Rocky Mountain area, long under dispute, appears to involve errors in establishing the vertical position of several of the floras involved, and doubtless of certain faunas as well. These errors are being corrected through the studies of Brown and Dorf. The age of the Auriferous Gravels on the western flanks of the Sierra Nevada was obscured by contradictory data until it became known that the floras range in age from Upper Eocene to Pleistocene. It seems clear that with adequate observation and critical analysis of their geographic and stratigraphic occurrence, Tertiary faunas and floras will provide chronological evidence in which no discrepancies appear. The very existence of such discrepancies as now appear is an indication of our inaccuracy of method or interpretation.

12. Dr. A B. Walkom, Sydney.

On the whole there seems in Australia to be little conflict between the evidence of plant and animal fossils in regard to the age of the beds in which they occur. I think the greatest difficulties result from consideration of small portions only of a fauna or flora and the use of such small portions as indicators of age. I think there is often too little

appreciation of the presence of 'hold-overs' in any fauna or flora, and quite frequently these 'hold-overs' are singled out and stressed as age indicators—in reality they will always indicate an age greater than the actual age of the beds in which they occur.

This, I believe, may be the case with the Wankie beds in Rhodesia where the *Pecopteris* and *Sphenophyllum* may not outweigh the *Glossopteris* flora in the determination of age.

There has been, during recent years, some controversy as to the age of the beds formerly called 'Permo-Carboniferous' in Australia, and the age of the *Glossopteris* flora. A recently published excellent analysis of the fauna in these beds in New South Wales (by Raggatt and Fletcher, *Records Aust. Museum*, xx, No. 2, p. 165) strongly supports the opinion that the whole of the system is of Permian age, and therefore the first appearance of the *Glossopteris* flora in Australia would be some 1,500 feet above the base of the Permian.

According to Mr. F. Chapman of Melbourne the evidence from the Foraminifera in the New South Wales 'Permo-Carboniferous' is that they range through Carboniferous to Permian in only a few cases, but are otherwise typically Permian. As far as Australia is concerned, then, it seems now that the Permian faunas and flora are in accord and there is nothing to support a suggested Carboniferous age for any of the *Glossopteris* flora.

13. Dr. Emily Dix, London.

*The Relative Values of Fossil Plants and Shells in correlating Coal Measure Rocks.*

The evidences afforded by fossil plants and shells supplement one another and should always be taken into consideration, whether in the identification of a particular coal seam over a small area or in establishing sub-zones or zones in rocks of Coal Measure age. When considering the identification of a coal seam one should examine all the evidence available: the character of the seam, the lithological characters of the roof and the associated measures, and the fauna and flora found in the roof shales. In cases where doubt exists a spore-analysis of the seam in question should be made. Thus, an ideal classification of the Coal Measures should be based on the vertical distribution of species of non-marine and marine shells, arthropods, plants and to a certain extent on the lithological characters of the rocks themselves.

It is generally true that the evidence afforded by either the non-marine shells or the plants may be a reliable guide to the correct determination of a zone or smaller unit of Coal Measure strata. But in other cases, difficulties arise owing to the great variation in the characters of the strata especially at some horizons, and as a result all possible lines of evidence should be taken into consideration.

In some cases the non-marine and the marine shells make possible the most detailed correlation, yet at certain horizons the plants are so characteristic that they are quite as valuable for correlation as the non-marine shells. In areas, too, where shells are rare, or absent, or where the species found are of no diagnostic value, the evidence afforded by the plants cannot be neglected, and is of necessity the more important.

On the Continent, it has been recognized for many years by such well-known research workers as Profs. Gothan, Renier, Jongmans and Bertrand that the distribution of the plant impressions found in the roofs of coal seams are reliable, not only for classifying the Coal Measure strata, but also for identifying individual seams. As a result it is customary in these coalfields to use the plants rather than the shells for zonal purposes. However, it has been shown by Prof. Pruvost and other workers that the results based on the non-marine shells were not in discordance with the results obtained by a study of the plant impressions. In this country,

on the other hand, a great difference of opinion arose between the workers on the plants and the shells with regard to the classification and correlation of Coal Measure strata in the various coalfields, which has made several geologists in Great Britain very sceptical indeed concerning the utility of either the plants or shells for zoning those rocks. Some have even expressed the opinion that no great changes took place in the characters of the floras and faunas as one proceeds upwards through the Coal Measures. This is a fallacy which is easily exposed. In my opinion the changes exhibited by the faunas and floras of the Coal Measures can be compared with those shown by the goniatites and associated faunas of the Namurian or with the corals and associated faunas of the Avonian—faunas which are recognized as reliable indices for zoning the strata in which they are found.

*Non-Marine Shells.*

Let us first consider the value of the non-marine shells, namely, *Carbonicola*, *Anthracomya*, *Anthraconauta* and *Naiadites*, (freshwater or estuarine forms which lived in the lagoons and estuaries of Coal Measure times) for (1) identifying coal seams, and (2) zoning Coal Measure rocks.

(1) *The Value of Non-Marine Shells for identifying Coal Seams.*—Dr. Wheelton Hind demonstrated that these shells could be used in correlating the Coal Measures of North Staffordshire, and he also gave an account of their broad zonal distribution in other coalfields in Britain. Mr. J. T. Stobbs extended his results in 1906, and for many years he has used these fossils in the identification of coal seams throughout the Midland Coalfields. However, he did not publish any further information concerning these shells, and thus it appeared that little attention was being given to these forms in Great Britain, and it was even suggested that they were of little value for correlating Coal Measure strata. Meanwhile Profs. Barrois and Pruvost investigated these molluscs in the North of France and other coalfields, and showed in 1919 that they afford most valuable data for zonal purposes. The classic paper published by Mr. J. H. Davies and Prof. A. E. Trueman in 1927 produced a great revival in the study of these lamellibranchs in Great Britain, and it is to the latter that we owe so much of our knowledge concerning the succession of non-marine faunas in the coal-bearing rocks of this country. He has also stimulated many others to become interested in them, with the result that a wealth of information is now available concerning the succession of those faunas in Britain.

In the roof shales of a great number of the coal seams in the British coalfields occur suites of non-marine shells. A detailed examination of these shells reveals marked differences in the species constituting the assemblages found in association with the various seams. The study of these forms and of the assemblages has made it possible for one to identify many coal seams over considerable areas. I could name a great number of seams which can be identified in this way, for example, the Lower Vein, Brasslyd Vein and Pennypieces in the western part of the South Wales Coalfield, where these lamellibranchs have proved of the utmost value to mining engineers in working out the complicated structures of that area. From the mining engineer's point of view, it is unnecessary to learn the scientific names of more than a few of these shells, but the general character of the assemblages can be memorized. It is a question of becoming accustomed to look-out for the typical forms in the assemblages, and this can only be accomplished by systematic collecting from various horizons. As one engineer has often remarked to me 'I don't care what you geologists name these shells, but I know that when I find these little fellows, the presence of the Brasslyd Seam is indicated, and when I find that group of mussels I am near the Lower Vein, and so on'.

Although the non-marine shells are of great value in identifying coal seams, it must be remembered nevertheless that certain shells are no

criterion of an horizon, and an odd shell or two in certain cases cannot be regarded as sufficient evidence for the presence of a particular coal seam. To quote Dr. W. B. Wright, 'The freshwater faunas on the different horizons of the Coal Measures have sufficient distinctness to lend character to the strata in which they occur, and if carefully used, with proper appreciation of their limitations as criteria of horizon, greatly facilitate local correlation'.

(2) *The Value of Non-Marine Shells for zoning the Coal Measures.*—In 1927, Davies and Trueman established a zonal scheme based on the vertical distribution of these lamellibranchs in the South Wales Coalfield. These workers proved that not only could individual seams be identified by means of these shells, but that faunas changed in character, by the appearance of new species and the extinction of others, as one ascended the sequence. As a result of further researches it has been proved that the broad zonal scheme established by Davies and Trueman can be applied in every area where Coal Measures occur in Great Britain. It is also applicable in France, Holland, Belgium, Westphalia and in the Donetz basin. Naturally slight modifications have become necessary as new material has become available, and various sub-zones have been recognized by Dr. W. B. Wright in Lancashire, certain of which have been traced into Scotland by Dr. J. Weir and Mr. D. Leitch. In cases where it may be impossible to identify individual seams in sinkings and boreholes, the recognition of the suites of shells found in the sub-zones may be of great importance to the mining engineer.

The zonal scheme put forward by Davies and Trueman, and later amplified by Trueman and Moore is as follows:—

| | |
|---|---|
| Stephanian (Westphalian E.). .. | (Zone of Anthracomya prolifora). |
| Upper Westphalian .. (C and D). | Zone of Anthraconauta tenuis.<br>Zone of Anthraconauta phillipsi. |
| *Great Change in Fauna.* | |
| Lower Westphalian .. (A and B). | Zone of Anthracomya pulchra.<br>Zone of Carbonicola similis.<br>Zone of Anthracomya modiolaris.<br>Zone of Carbonicola ovalis.<br>Zone of Anthracomya lenisulcata. |

Fossil shells are unknown in the uppermost Coal Measures of South Wales, but in the corresponding beds in Radstock, Prof. Trueman and Dr. Moore have described a series of shells including *Anthracomya* aff. *prolifera*, which supports the conclusion based on other evidence that the strata in question should be attributed to the basal beds of the Stephanian (or Westphalian E. of Jongmans and Van der Gracht).

### *Marine Faunas.*

At intervals regional subsidence was sufficient to cause a transgression of the sea over the low-lying swamps. Sometimes the first marine form to appear was *Lingula*. *Lingula* beds and all marine beds generally overlie coal seams of varying thicknesses from ¼ inch up to a foot. *Lingula* beds are often impersistent, and they may pass laterally into shales containing *Carbonicola* and *Anthracomya* or shales with a more typical marine fauna, consisting chiefly of goniatites, nautiloids and lamellibranchs.

Our knowledge of the marine faunas may be attributed to the work carried out by Dr. Wheelton Hind, Mr. J. T. Stobbs, and especially by Mr. W. S. Bisat. Some of the marine beds are widespread, and are fairly frequent in the lowermost Coal Measures, especially in Yorkshire and Lancashire. Two well-known bands occur, namely, the one in the

roof of the Pot Clay Coal (the *Gastrioceras subcrenatum* Marine Bed) and the other in the roof of the Halifax Hard Seam (the *Gastrioceras listeri* Marine Bed), which forms a well-marked datum plane in Yorkshire, Nottinghamshire, Derbyshire and Lancashire, and is also equivalent to the Finefrau Marine Bed on the Continent.

Many other marine beds have been noted in various coalfields in Great Britain in the lower part of the Middle Coal Measures, for example, the Amman Marine Bed in South Wales, which can be traced over a wide area and has been of great economic importance in correlating strata in that portion of the sequence. Some of the other marine beds in the lower part of the Middle Coal Measures are only of limited extent, and although they may be useful in identifying a seam in any particular coalfield or a part of a coalfield, they cannot be used for correlation over considerable areas. Very important marine beds, however, occur near the top of the *Similis- Pulchra* Zone of Davies and Trueman in all the coalfields in Great Britain where the sequence is known, and similar marine beds occur at comparable horizons in France, Belgium, Holland and Westphalia.

Naturally, owing to the scarcity of marine beds in the main portion of the Coal Measures and their complete absence in the uppermost measures, and especially owing to the rarity of cephalopods, marine beds cannot be regarded as ideal fossils for zoning Coal Measure rocks, although they afford the most useful datum planes for wide-scale correlation and can be used for checking conclusions based on other fossils.

### *Fossil Plants.*

Let us next consider the evidence afforded by fossil plants in (1) identifying coal seams, and (2) for zoning Coal Measure strata.

(1) *The Value of Fossil Plants for identifying Coal Seams.*—

(*a*) In the first instance there are the petrifactions found in the coal-balls (calcareous concretions found in certain seams with beautifully preserved masses of vegetable material). These coal balls are restricted to a few seams in the Lower Coal Measures of Lancashire and Yorkshire, but they also occur at a comparable horizon in Holland, Belgium and Westphalia. However, in this case the evidence provided by a study of the petrifications simply supports the identification of the seams based on the presence of the balls in the seam and on the the marine character of the roofs of the seams with their bullions and peculiar marine fossils.

(*b*) It has been found that most coal seams contain certain plant-spores which characterize them and which distinguish them from other seams. While certain spores may be common to several seams, there are usually a few types found only in one seam. Thiessen and his co-workers in America, Lange in Silesia, Dr. Slater, Miss Evans and Miss Eddy and Dr. Wray in Britain have correlated seams based on their spore-content. Their work has been chiefly based on the observations of microspores and more particularly macrospores in thin sections of coal. More recently Dr. Raistrick has carried out laborious and detailed researches on the quantitative analysis of microspores found in the various seams, and in this way he has been able to correlate seams over a considerable area in Northumberland and Durham. In my opinion, caution should be observed in identifying seams purely on the quantitative spore-content, especially seams in widely separated areas. We do not yet know enough about the parent plants of the spores, and the variation in the spore crop may be due to local associations in the coal forests.

(*c*) The evidence afforded by the fossil plants found in the roofs of coal seams (incrustations, impressions) has been used in the identification and correlation of coal seams. Their use has been criticized on the following grounds: (i) their fragmentary character, (ii) they represent

drifted material, (iii) they are rare as fossils at many horizons, (iv) there is no marked change in the species of plants in passing upwards through the Coal Measure rocks. In spite of the fact that plants are fragmentary and that they usually represent drifted material, they represent in fair measure the flora at the end of the forest period and they can tell us a great deal about the flora of the period. Plant impressions are unquestionably rare at some horizons; nevertheless they occur in great abundance at others, and even when they are not plentiful they often throw a great deal of light on the position of the beds in the sequence.

I must admit that I was rather pessimistic about the utility of these fragments until I proved that, with a knowledge of the floras found in their roofs, I could trace certain coal seams over a distance of 20 miles. The most convincing proofs of the value of these impressions has been brought home to me through my good fortune in having opportunities to collect plants in several coalfields in Great Britain and in France, Germany, Belgium and Holland.

When using plants for correlating coal seams, the composition of the whole floral assemblage should be considered and much attention paid to the occurrence of rare species. Several species range through hundreds of feet of strata, and these are frequently amongst the commonest fossils in some assemblages, for example, certain species of *Calamites* and *Stigmaria*. Naturally these plants cannot be used for zonal purposes, yet the presence of a number of fairly long ranged species may occasionally assist one in identifying a seam over a small area, for example, masses of *Sigillariophyllum* in the roof of the Gower Lynch Seam. As in the case of quantitative methods used in the microspore analysis of a seam, so there is a danger in using a purely quantitative analysis of the fragments of plant impressions found in the roofs of coal seams. It is difficult for instance, to say how many *Neuropteris* pinnules should be the equivalent of a *Calamite* stem, and therefore it may be impossible to estimate the percentages of the plants in the assemblages.

(2) *The Value of Plants for Zoning Coal Measure Strata.*—

As a result of detailed studies of the plant impressions we know that the floras of certain periods of Coal Measure times were remarkably similar in widely separated areas from America to the Donetz basin, and that the floras changed in character by the evolution of new forms and the disappearance of others at successive horizons (this has been verified in Great Britain by the work carried out along different lines by Dr. Raistrick and others). The floras become richer and more complex as we proceed upwards through Coal Measure rocks, and they are especially varied in the Middle Coal Measures, where the maximum number of species are recorded. Although the floras were remarkably uniform, yet we know that plant associations existed, governed, may be, by physical conditions or centres for dispersal of new species; there are plants found in North America which are unknown in Britain and *vice versa*, while there are fewer differences between the floras of South Wales and the North of France. Such plants, however, as *Pecopteris aspera* and *Pecopteridium defrancei* occur in particular beds in France, but are unknown in Britain, while *Lonchopteris rugosa* is abundant at certain levels in Holland, Belgium, and in Westphalia, and is common at only one locality in the Bristol Coalfield in Britain.

The utility of fossil floras for subdividing Coal Measure rocks has been recognized for a very long time by workers such as Zeiller, David White, and more recently by Gothan, Renier, Jongmans, Bertrand, Zalessky and Darrah. In this country the great pioneer work on the stratigraphical aspects of palæobotany was carried out by Kidston. Arber also contributed much on this subject. Kidston recognized a succession of different floras in the Coal Measures, and suggested the following classification in 1905:—

| | |
|---|---|
| Upper Coal Measures | Radstockian Series |
| Transition Coal Measures | Staffordian Series |
| Middle Coal Measures | Westphalian Series |
| Lower Coal Measures | Lanarkian Series. |

Later he subdivided his Staffordian and Radstockian Series. Unfortunately Kidston had little knowledge of stratigraphy, and as a result he attributed floras to the wrong portion of the sequence. I believe that he realized many of his mistakes before he died, and that, had he lived a while longer, he himself would have redescribed the succession of floras found in our Coal Measures. In recent years much more information has been obtained concerning the floras of the Coal Measures through the researches of Dr. R. Crookall, Mr. W. D. Ware and others, and they have assisted me from time to time in my work. It has been shown that the Upper Carboniferous of the Swansea area of the South Wales Coalfield can be subdivided into nine floral zones, indicated below. These floral zones can be traced into other areas in Britain, and, moreover, they compare closely with the floral divisions recognized on the Continent and in North America.

| | |
|---|---|
| FLORA I | Zone of Pecopteris (Asterotheca) lamurensis<br>Acitheca polymorpha<br>Dicksonites pluckeneti<br>Mixoneura (Odontopteris) sp.<br>Alethopteris grandini<br>Sphenophyllum oblongifolium |
| FLORA H | Zone of Mixoneura (Neuropteris) ovata<br>Neuropteris scheuchzeri<br>Neuropteris flexuosa<br>Odontopteris lindleyana<br>Alethopteris serli<br>Asterotheca arborescens<br>A. miltoni (Pecopteris abbreviata)<br>Sphenopteris neuropteroides<br>Sphenopteris macilenta<br>Diplotmema geniculatum<br>Sphenophyllum emarginatum<br>Annularia stellata |
| FLORA G | Zone of Neuropteris rarinervis<br>Neuropteris linguæfolia<br>Linopteris munsteri<br>Mariopteris sauveuri<br>Mariopteris latifolia<br>Sphenopteris striata<br>Renaultia chaerophylloides<br>Asolanus camptotænia |

*Marked Change in Flora*

| | |
|---|---|
| FLORA F | Zone of Neuropteris tenuifolia<br>Neuropteris callosa<br>Asolanus camptotænia<br>Lepidodendron simile |

| | |
|---|---|
| FLORA E | Zone of Lonchopteris rugosa<br>Neuropteris gigantea<br>Sphenophyllum myriophyllum<br>Sphenophyllum majus<br>Annularia microphylla<br>Sphenopteris spp. |
| FLORA D | Zone of Alethopteris lonchitica<br>Neuropteris heterophylla |
| FLORA C | Zone of Neuropteris schlehani<br>Lyginopteris hoeninghausi |
| FLORA B | Zone equivalent to the Pecopteris aspera zone of the North of France |
| FLORA A | Zone of Lyginopteris stangeri<br>Alethopteris cf. parva. |

In using fossil plants to divide the Upper Carboniferous rocks into zones sufficiently thin to be of real value in correlation, attention must be given chiefly to those species with short ranges; frequently these species are rare except at a few horizons, and, since their distribution is incompletely known, the precise boundaries of certain of the zones cannot be definitely fixed. The boundaries of most of these zones must be regarded as rather indefinite, and further research may lead to slight modifications of some of them.

These broad subdivisions based on the distribution of the plant impressions agree very closely with those established by Trueman and other workers on the non-marine shells and by Bisat on the marine faunas.

In concluding one would like to express a word of warning to those who expect too much of the fossils, especially from the point of view of correlating coal seams. The evidence afforded by the fossils is invaluable to the mining engineer and geologist, but it is necessary to recognize their limitations. Odd shells, or individual plants, or forms of no diagnostic value can seldom give the answer to the problem. Some seams can be correlated over wide areas, but there are many which are of limited extent, and owing to the variation in the character of the Coal Measure strata caution should be observed in attempts to correlate too many of our coal seams over considerable areas. Perhaps the scepticism which is expressed by some geologists concerning the utility of these fossils for correlation may be attributed to the economic value of coal and the fact that subsequent mining operations can always prove whether the answer given by the fossils has been correctly interpreted or the contrary. It is possible that such fossils as the graptolites of the Palæozoic or the echinoids of the Cretaceous might risk the reputations attributed to them if boreholes and sinkings in quest of economic wealth were put down at more frequent intervals in the strata in which they are found. Nevertheless, it has to be admitted that palæontological evidence is more reliable than lithological data for correlating the Coal Measures or any other strata; and that what Prof. W. W. Watts has recently termed 'the great principle of the identifications of rocks by fossils, on which are built the widest generalizations of geology' is as triumphantly vindicated by the fauna and flora of the Coal Measures as it is by the fossils of other ages.

14. Dr. Rajnath of Benares and Prof. W. G. Fearnsides of Sheffield also spoke.

15. Prof. B. Sahni, Lucknow.

*Concluding Remarks.*

More than one contributor has referred to possible discrepancies due to differing rates of evolution in plants and in animals. The rate of evolution is a question of such baffling complexity, with so many interlocking factors which defy analysis, that I hesitated to venture upon a discussion of this aspect.

Does palæontology teach us that in the course of geological time plants as a class have evolved at a different rate from animals? If so, have the one or the other class of organisms consistently evolved at a faster rate, or have plants sometimes evolved faster and sometimes slower than animals? The view has been expressed by Dr. Stanton (p. 172) that 'modern types were introduced somewhat earlier among plants than among animals', and that 'therefore, in America at least, the boundaries between systems and other major geologic divisions when based upon the plant-remains are often placed somewhat lower than the faunal evidence would indicate'. On the other hand, it has been suggested by Professor Cockerell (p. 174) that animals evolve more rapidly than plants. Can either of these statements be made to apply generally, or do they refer only to restricted groups, areas and periods?

Much recent work tends to show that the rate of evolution is not a specific quality predetermined and fixed for each plant or animal but is influenced by the environment in the widest sense. This may be taken to include changes in the soil and climate, as well as those in the biotic factors such as the interdependence of plants and animals, competition within and between species, natural hybridization, etc., etc. This being the case we may conclude that the pace of evolution must have varied in a complex manner even within narrow circles of affinity and in both space and time. Some groups may, while others may not, have altered their previous rates of evolution, and this change may have occurred in restricted areas only. If this was so it is clear that we cannot always speak of a given species (and much less of a given group) of plants or of animals having altered its rate of evolution, because the group or the species may have been distributed over a larger area than that where the environment underwent change.

It is almost a truism to say that evolution must be slower in a relatively static environment, e.g. in the middle of large climatic areas, and faster in dynamic environments such as the sea-coast or along the fringes of climatic zones like the Sahara and the glaciated regions. The recent observations of Hagerup, Tischler, Müntzing and others bear eloquent testimony to this. Apart from the direct effect which has been experimentally proved of the temperature and other factors in producing polyploid and other mutations, there is, along these borderline regions, more conflict and competition, and a wider scope for hybridization.

The greater mobility of animals might at first seem to suggest that they should be less readily adaptable than plants. Because plants move more slowly it might be thought that they must more often perish than animals in an adversely changing environment. But it appears to me that there is a fallacy here. Except in the case of local cataclysms (which cannot be of any significance in this connexion) the rate at which an environment undergoes change is probably never so rapid that, while the animals inhabiting an area can easily migrate, the plants must either perish or eke out a precarious existence with the possibility of getting acclimatized. I think we may take it that in plants, as well as in animals, there is a constant centrifugal urge along the fringes of the areas of dis-

tribution. The seeds of plants are usually already spread beyond the normal distribution areas of the species. Their failure (under static conditions) to extend the distribution of the species is not due to *non-arrival* but to *non-survival* of seed beyond the normal area of distribution. But when the environment (say, the climate) undergoes change these seeds would be able to germinate and the border lines of distribution would be adjusted accordingly.

Thus we may conclude that the rate of horizontal spread of species is always faster than the rate of movement of any large environmental change. Hence it would seem that for purposes of effective migration plants, although less mobile in the ordinary sense, are probably not slower than animals.

From what I have said it seems that we cannot speak in general terms about plants and animals as a whole evolving at different rates. Nevertheless the local preservation of residual forms may tend to cause slight discrepancies. Such forms therefore deserve special attention.

Referring to Mr. Crookshank's remarks, I am glad he also thinks that Dr. Spath is not justified in extending to the Rajmahal flora in Behar the conclusions he has drawn from an examination of the Madras Coast ammonites. I may, however, be forgiven if I find it difficult to endorse Mr. Crookshank's palæobotanical reasons for this view. My difficulty is (as I said in my opening remarks) that we do not yet know enough of the Jabbalpur and Umia floras to be able to make any helpful comparisons with the Rajmahal flora, which is now fairly well known.

The modern tendency in palæobotany is not greatly to reduce the number of species based upon leaf impressions, as Mr. Crookshank believes, but, I fear, it is just the reverse: with intensive work on the cuticles and fertile parts of these leaf 'impressions' the number of species is steadily mounting up. The specific instance of *Ptilophyllum acutifolium* chosen by him is particularly unfortunate because it is just here that recent work has helped to split up that 'species'. The name *P. acutifolium* was formerly applied in a comprehensive sense to a number of different types of cycadean fronds which were grouped together merely on grounds of convenience.

## XXXI. THE ABSORPTION OF SALTS BY PLANTS.

*(Sections of Botany and Chemistry, in co-operation with the Society of Biological Chemists, India.)*

PROFE. V. H. BLACKMAN, London, presided, and PROF. P. PARIJA, Cuttack, opened the discussion.

1. PROF. P. PARIJA. Cuttack.

### *Opening Remarks.*

The problem of absorption of salts by plants is of such great theoretical and economic importance that no justification is necessary for the choice of this subject for a joint discussion. On behalf of the President of the Botany Section I have the honour to invite the distinguished scientists present here to discuss this very important problem in all its aspects so that scientific workers in pure and applied plant physiology all over the country may get light and guidance in their further search for knowledge.

As a humble student of plant life, I can only put before you some points which may serve as the nuclei for discussion.

Salts, or should we say ions, are absorbed by root hairs, rhizoids or other absorbing organs. Any factors which will affect the growth of these absorbing structures will affect the absorption. Thus, for example, 0·3%

NaCl will produce an average root hair length of 30 as compared to 6 in $KNO_3$ of the same concentration while Boric acid (0·02%) will produce 45 in *mustard*. Other external factors will also influence absorption.

Apart from these, the living cells do manage to take in and sometimes accumulate ions inside them (case of *Valonia* by various authors) in excess of the outside concentration.

There are various aspects of this problem. I want to invite your attention to only a few points which I think deserve more consideration than they have received.

In absorption of salts, the surface cells of the absorbing organs, be they roots, haustoria or submerged organs of water plants, are all important. It is taken for granted that the walls of these cells do not play any other part except exerting what is known as the wall-pressure when the cells are turgid. That is to say, the cell-wall only plays a passive rôle.

Now the question is whether the cell-wall is really passive. The cell-wall is after all a colloidal sheath and as such its physical condition is subject to modification according to the constituents of the solution that bathes it. What part do these modifications play in the process of absorption ?

*The Cell-Wall*—not homogeneous. In cross section various striations are visible, sometimes quite easily. Kerr and Bailey point out that even the middle lamella consists of three layers. Stratification, according to the micellar theory, is the result of the arrangement of micellæ.

The most widely held idea is that the micellæ are crystalline (Frey, Wyssling, Meyer, Herzog and Clark) and these submicroscopic micellæ are packed, so to speak, in a hydrophylic colloid.

Thus apart from the lamellation which one sees in the cell-walls of algæ, there is heterogeneity even in each lamella and the intermicellar spaces are liable to alteration and thereby increase or decrease the permeability of the cell-wall (Gurewilsch).

If this is true of cell-walls of absorbing organs then do these various interfaces have any influence on the absorption of salts ?

Is the cell-wall really passive ? Some workers like Lloyd have doubted this especially in the case of algæ.

They even go so far (Lloyd and Ulehla in *Postelsia* Crammer) as to regard the cell-wall as a living structure subject to irreversible changes like death. More attention must be paid to the cell-wall than has hitherto been done.

There is another point with regard to the cell-walls which deserves attention. We are apt to leave out of consideration the gelatinous sheath of the walls of many absorbing cells (e.g. blue-green and green algæ).

Again in the lamellated cell-walls, such as one finds in some algæ, the interfaces between the lamellæ may not be without influence on the absorption.

(1) One is confirmed in one's doubt as to the passivity of the cell-wall, when one remembers how intimately the cell-wall and the plasma membranes are connected and the influence which different salts and their concentrations have on the development of the root hairs.

(2) We have next to turn our attention to the all important plasma membrane. The plasma membrane is admittedly a colloidal mosaic of proteins and lipoids. The unidirectional growth of root hairs indicates that the plasma membrane is not of uniform composition all-round the piliferous cell.

*Plasma membrane.*—Passing from the cell-wall, one comes to the all-important plasma membrane. This membrane is admittedly a colloidal mosaic of protein and lipoids, which is not of uniform composition all-round the absorbing cell, as shown by the unidirectional growth of root hairs.

This membrane is closely adpressed to the cell-wall. As we have seen before, the cell-wall is traversed by transverse submicroscopic passages of hydrophilic colloids. Whether these colloidal passages are ramifications of the plasma membrane as some people think ?

If this is so, then the real region of study shifts from the plasma membrane to the surface of the cell-wall. That there is intimate connection between cytoplasm and the cell-wall is shown sometimes at sudden plasmolysis where strands of cytoplasm are torn out.

If these hydrophilic colloids are not continuous, then what part do they play in the passage of salts?

Energy must be expended to maintain the colloidal complex constituting the plasma membrane in efficient condition. The fact that the root hairs in higher plants grow, live and die means that this necessary energy supply somehow fails or possibly the very salts which are absorbed in the process of absorption bring about an irreversible change in the colloidal complex, thus bringing about death.

(3) The next point to be remembered in a multicellular organism is the correlation between the surface cells and those in the interior.

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2. Mr. B. Sen, Calcutta.

*Living protoplasm and the plasma membrane.*

The quantity of salts absorbed by plants can be followed accurately by measuring under controlled conditions the diminution of solute concentration of the culture medium. But when we consider the *mechanism* involved in this process of absorption, we have to struggle more with theories than well-established conclusions.

The epidermal cells of the absorbing tissue are the primary units through which absorption of salts takes place in plants. The cell-wall is now generally accepted as freely permeable to both water and solutes; it is the plasma membrane of the cell which functions as the selective barrier for all entering ions. Therefore the plasma membrane is the most important determining factor involved in the process of salt absorption by plants.

The most recent general discussion on the subject of the 'Properties and Functions of Membranes, Natural and Artificial' (*Trans. Faraday Soc.*, 1937, **33**, pp. 911–1148) has reminded us, however, that (i) most of the problems concerned with the structure and functions of the plasma membrane still remain unsolved, despite several very suggestive theories advanced and many admirable models devised; and (ii) more definite information about the nature of living protoplasm itself is badly needed, before further speculations can become really fruitful. Conclusive experimental data about the most elementary physical properties of protoplasm are surprisingly meagre and often contradictory. It is now generally accepted that protoplasm is a colloidal complex, but agreement is lacking as to whether it is a suspensoid or an emulsoid. Similar disagreement is to be found regarding its viscosity, that is, whether protoplasm is a sol or a gel. The very existence of the plasma membrane as a distinct morphological entity is still being questioned by some.

Elsewhere (Sen, B. 1934, *Ann. Bot.*, **48**, 143–51; 1937, *Ind. Jour. Agri. Sci.*, 7, 479–485) the writer has enumerated the difficulties inherent

in experimental observations on living protoplasm, as also the special facilities which root hairs of *Azolla pinnata* afford for ultramicroscopic observations on living protoplasm. An *Azolla* root hair is practically a cellulose capillary filled with transparent protoplasm. For the present discussion, the results of my observations on living protoplasm and the plasma membrane may be summarized as follows:

(1) The ultramicroscopic picture of living protoplasm of *Azolla* root hairs shows bright particles in vigorous Brownian movements.

(2) The colloidal particles of living protoplasm of petiole hair of the stinging nettle (*Urtica dioica*), root hairs of *Azolla*, tubes of germinated pollens (unpublished data) of Sweet Peas (*Lathyrus odoratus*), *Petunia*, and Madonna Lily (*Lilium candidum*) are *negatively charged*, as found from their cataphoretic migration. This charge remains negative as long as the protoplasm maintains its living structure.

(3) Bivalent cations, in isotonic concentrations, when injected by micro-pipettes or introduced inside the protoplasm by the Increased Permeability technique, induce irreversible flocculation. Ca and Sr exhibit specific reactions not shared by Ba and Mg.

(4) The viscosity (unpublished data) of *Azolla* root hair protoplasm, as determined by camera lucida tracings, on a uniformly moving horizontal plate, of Brownian movements of single particles, is found to be of the order 3 to 4 times that of water.

(5) The dispersion medium of the living protoplasm of the different cells investigated, appears to be an aqueous solution, and the immiscibility of protoplasm and water is due to the presence of a membrane. When this membrane is destroyed, the protoplasmic mass diffuses freely in water and aqueous solutions (unpublished data).

(6) The morphological existence of a plasma membrane, differing in chemical composition from the bulk of the protoplasm, has been demonstrated (unpublished data).

(7) The normal plasma membrane of *Azolla* root hair and also membranes formed round beads of protoplasm of plasmolyzed hairs show similar reactions to different cations, and the permeability of both increases when they are effectively stimulated by an induction shock (unpublished data).

These data indicate that, at least within the visible limits of the ultramicroscope, the protoplasm of the cells studied exhibits more of the properties of a suspensoid than of an emulsoid.

3. Dr. S. Ranjan, Allahabad.

The subject of salt intake by plants is a very vast one, presenting many aspects for consideration. The entrance of salts is influenced by various internal and external factors. There is also evidence to believe that the absorption of salts is not only intimately connected with the nature and composition of salts but also with those of the living protoplasm.

Thus the problem of salt intake is more to be looked at from the physiological point of view than from the purely physical. The older theory that inorganic salts enter plant cells in the dissociated or ionic state only is quite untenable in view of the works of Irwin, Osterhout and others which indicate that in certain cases at least compounds in the undissociated form have the power of entering the cells. It is generally thought that the entry of salts is made possible because of concentration gradients—salts diffusing from the medium of higher concentration to one of lower in respect of these salts. It is contended that the concentration of soil solution in respect of these salts is higher than that of the cell sap. But such a condition cannot exist indefinitely unless the salts entering are translocated away or are somehow rendered osmotically inactive; otherwise sooner or later a state of balance will be attained. Moreover it has been definitely proved that *Chara* and

*Nitella* cells have the power of accumulating certain salts in concentrations higher than those in the external solution.

Breazeale postulates that it is the colloidal particles of the protoplasm with a definite electrical charge that are instrumental in effecting entrance of salts. The charge is transferred from its place of origin to the epidermal cells of the roots where it must be satisfied; therefore the oppositely charged particles must be absorbed. It must be noted here that colloids are heterogeneous systems of unstable equilibrium, the particles being dispersed in the suspending liquid because they carry the same electric charge. The effect of ions on the colloids is to disturb their electrostatic equilibrium. It is, therefore, not difficult to imagine a complex system of anions and cations within the plant cells which operate in such a way as to effect the entrance of salts or rather dissociated salts.

It is also quite conceivable that protoplasmic rotation may have something to do with the intake of ions. Lapique considers that by rotation each portion of the protoplasm of the cell is alternately brought in contact with the external solution and the vacuolar sap. It is well known that proteins, one of the constituents of the protoplasm, are amphoteric compounds and on the acid side of the iso-electric point combine with anions and on the alkaline side with cations. It therefore seems that the absorption of ions is a function of the protoplasm itself through its constituent proteins. The work of Pearsall and Ewing lends weight to such a conception of ionic intake. The intake of salts or ions is therefore a direct metabolic phase of the living cell—accumulation being effected at the expense of metabolically derived energy. The conception of cell-colloids as having to do with the absorption of ions might possibly be correlated with the absorption of nitrate and ammonium nitrogen. It has been contended that these two forms of nitrogen are absorbed at different hydrogen ion concentrations of the medium. This suggests that the cell-colloids are oppositely charged at the time of the intake of these two forms of nitrogen respectively. Thus there is evidence to believe that nitrate nitrogen is absorbed at a relatively high concentration of hydrogen ions—probably in the neighbourhood of pH5, while ammonium nitrogen is taken in at a lesser acid or even alkaline reactions.

4. Prof. V. H. Blackman, London.

The view I wish to stress is that the absorption and accumulation of salts by plants is a dynamic process, not a question of equilibria. Work must be done to attain a higher concentration inside the cell than without it. We know that certain plant cells such as hairs can secrete almost pure water from a concentrated cell sap. Similarly the kidney secretes weak salt solution, the urine, from a strong salt solution, the blood. Work must be done in these cases and the energy for that can come only from metabolic processes.

The absorption of salts by plants cannot be explained by passive models of membranes with certain permeability characteristics. Such models simplify the problem so that it has little relation to reality.

The work of Steward with potato slices has shown that absorption is closely related to aeration and to the rate of $CO_2$ output, i.e. to rate of respiration. This clearly demonstrates the relationship of accumulation of salts to the rate of metabolism.

Tissues such as bulb scales and the flesh of the apple fruit have no power of growing and dividing and fail to accumulate Br. from Pb. Br. even under favourable conditions of temperature and aeration. Such tissues produce $CO_2$ but do not accumulate salts yet in the Osterhout model the exit of $CO_2$ is an essential part of the mechanism of accumulation of potassium. Again, *Nitella* and *Elodea* in the light actively accumulate the bromide ion yet $CO_2$ is not passing out but entering the cell.

Uptake of salts must be studied in *relation to the whole cell,* not merely in relation to the cell wall or to the protoplasmic living layer. The problem is not yet in a state of development suitable for chemical or physicochemical analyses.

5. DR. B. N. SINGH, Benares.

The phrase 'absorption of salts by plants' may easily imply a range of investigational activities entirely too broad to be discussed in a single discourse specially one so strictly limited as to its length. In a study of the mineral nutrition of a plant there are many factors which must be considered for the intake of nutritive elements involves complex chemical and physical processes. It has become evident during recent years that the absorption and accumulation of elements by the plant cell in the course of their normal nutrition involve processes which may easily escape proper study in so far as most investigations on permeability of cell membranes are concerned. The investigator of the permeability of plant cells is often constrained to employ highly artificial environmental conditions (high concentration of solutes, use of solutes foreign to the cell, unsuitable conditions of light or aeration, etc.), or to work over very short periods of time. Investigations of such nature have their own limitations and hardly serve to elucidate the gradual intake of electrolytes by the growing or actively metabolizing plant.

Much work has been carried on covering several years on the intake of certain more important elements and it is now definitely indicated that of all elements potassium has been universally found at concentration in the cell sap much higher than that in the external solution. The evidences collected during the past ten years on the absorption of this element by apparently closely related and similar species and varieties of crop plants chiefly of the Gramineæ order, when grown in culture media of similar mineral constitution, indicate how widely the rate of absorption differs with the variety as well, and in certain cases with the individuals of the same variety. Evidently highly generalized statements with regard to the physical chemical properties of the different chemical elements in relation to their intake by plant cell must be made with caution.

Among the factors that vitally determine the absorption of salts from liquid media, the aeration of the solution has been shown to be most important. While conducting a series of very carefully controlled studies on the absorption and accumulation of certain elements, it has been definitely shown that the respiratory activities of the root cells are indispensably involved in the process of accumulation. Significant differences in the rate of absorption in different varieties of the same plant did not occur except when the medium was suitably aerated. Under conditions of proper aeration favouring optimum respiration of the delicate rootlets and root hairs striking differences were obtained. In all these experiments aeration of solution did not merely carry away the $CO_2$ evolved by the roots but also supplied oxygen for proper respiration. Maximum accumulation of electrolytes was attained under those conditions which provoked maximum aerobic respiration of the root. Excised roots of these very plants too show but little or no power to accumulate electrolytes under non-aerated conditions whereas under proper aeration seedlings accumulate these ions very rapidly. In all such cases it has also been marked that the metabolic state of the roots as determined by culture conditions existing previous to excision is also of great importance.

It has further been demonstrated that while the absolute amount of solute absorbed by the plant increases with increasing concentration of the solute in the external solution, the amount absorbed relative to the external concentration nevertheless decreased rapidly from the lowest concentration upwards. When the external concentration of the solute is low the absorption rates become more than unity, while under high external concentrations, the absorption rate is always less than unity.

The degree of absorption depends not only on the concentration of the external solution but also upon the nature of ions absorbed. Thus the absorption of nitrates cannot be considered independently of the absorption of cations inasmuch as their effect on such plant characteristics as protein content of wheat are concerned. The quality in protein is known to vary with the character of the culture media, the nature of nitrogenous salt supplied and particularly the concentration of the nitrate ions in the medium as expressed by the results of extreme conditions of no nitrate on the one hand and ample quantities of nitrogen salts on the other.

The reaction of the solution is another important factor in the absorption of salts. Investigations in this regard have shown that for each species and variety of the crop plants there is a specific range of *p*H at which optimum absorption takes place. Toxicity is more likely to occur if in spite of other favourable conditions the acidity of the sap is not maintained within certain range of the optimum for the species.

Light has particularly been shown to influence the intake of K and N ions. With increase in either the intensity or the duration of artificial illumination, it has been found that wheat plants grown in water culture accumulate more of those ions. Above a certain range of intensity and duration the reverse effect is clearly noted. This indicates how a purely external factor has influence on the absorption of the simple inorganic entities.

Temperature of the medium too introduces significant differences in so far as the total quantity of solutes absorbed by the plant is concerned. Thus in three series of cultures of wheat grown at 45, 35 and 30°C., respectively it has been shown that the total ash content after a period of 45 days increases with the increase in the temperature of the culture from 30 to 35°C., and later exhibits a marked decline. This optimum temperature was found useful for all studies on absorption.

Humidity of the atmosphere has also been found to greatly regulate the intake of solutes from the soil but it cannot be said with certainty whether it has any direct effect on the intake of solutes. When grown in an environment with humidity above 75% wheat plants failed to absorb as much of nitrogen from the medium as under relatively drier atmospheres (50% humidity). Such variations in the absorption rate are correlated with the transpiration values under the two conditions but it cannot be vouchsafed for the present that the evaporation of water from the plant has any direct bearing on the rate of absorption of ions.

Of special interest in this connection is the relation between the intake of solutes and the metabolic needs of a growing plant. The data collected in this connection indicate that in a majority of cereals and few other plants, the absorption of soil constituents is characterized by three distinct phases, co-extensive with the more important stages of vegetative development. The first of these covers a period of progressively increasing rate of absorption ending about the time the heads begin to form. At this time it is frequently observed that the absolute amount of potassium and nitrogen contained in the plant approach the magnitude present at complete maturity. The beginning of the second phase is indicated not merely by a decreased rate of absorption but by definite and substantial losses of certain constituents notably potassium, nitrogen and calcium from the portions of the plant growing above the ground and presumably from the entire plant. The loss is more or less concurrent with the migration of the same constituent into developing heads. The end of the second phase is characterized by a tendency to absorb again the soil constituent previously lost. This may result in taking up considerable quantities of these elements when the plants are large and well developed. The third phase occurring at the time of the ripening of the grain is marked by a practically complete cessation of absorption of all constituents and an actual loss of most of them.

While such cyclic variations in the absorption rates of certain elements characterize different species and varieties of plants experimented upon, it may incidentally be remarked that specially in soil and sand fertilizer cultures, the losses of potassium and nitrogen at certain stages of the life cycle occur when the constituent of the water extract of the soil were at or approaching their minima and when the same constituents were moving from leaves to the heads. Much, however, depends upon the specificity of the plant material, the specific needs of the plant at various stages of growth and development, and the relation which the process of absorption might have with other metabolic activities of the plant.

Attention may specially be recalled at this stage to the characteristic relation between the age-factor and rate and order of absorption of ions on the one hand, and the relation between the intake of certain elements specially potassium and calcium and the photosynthetic efficiency of plants on the other. While the ions in case of one single species are not absorbed at the same rate and in the same order at successive stages, there does seem to exist some correlation between the quality of these absorbed and the specific metabolic rate. Thus a higher rate of absorption of potassium and calcium has always been shown to be associated with a higher rate of photosynthesis and *vice versa*.

The phenomenon of the relative intake of nutrient elements from culture solutions is further complicated by the antagonism between different ingredients, the unequal absorption of component ions and the selective absorption of these ions by the species under consideration. In considering this aspect, however, we cannot but take into consideration the quality and state of protoplasm more particularly the amphoteric nature of plant proteins, the biochemic constitution of the species, and the nature of the particular stimuli—physical, chemical or mechanical, the effect of which is being investigated.

The whole question as a matter of fact remains yet to be carefully analyzed and unless large amount comparative data under different conditions and stimuli specially from water culture experiments, sand water culture, soil pot cultures, field experiments and so on, and under as many different combinations of factors as practicable are available, it is rather difficult to arrive at any definite generalization. Strictly controlled experiments with a parallel study of the different plant processes directly bearing upon the question of absorption of salts might also aid in solving the still little understood processes connected with the intake of ions by plants. It is also desirable to call attention to the extensive investigations of Mason and Maskell. They suggested that re-export towards the roots of certain elements *via* the phloem may have a bearing on the rate of absorption of such elements by the root cells. The relation or lack of relation between transpiration and absorption of mineral elements is also thought to be involved. The absorption of these elements may thus involve problems of plant anatomy as well.

Summarizing the whole question it may be remarked that the mechanism of living cells involved in the absorption of salts, which is undoubtedly of exceedingly great intricacy, has not yet been disclosed through any direct experimental approach although we have before us many of the suggestive explanations of the phenomenon put forward by various workers from time to time. Among the theories advanced during the past few years mention may be made of the ionic exchange theory of Brooks and Briggs, Osterhout's conception of undissociated molecules entering the root cells, Breazeales's theory of physical absorption, the epictesis theory of Lapique, etc. The conception of a simple Donnan equilibrium too is inadequate to explain the phenomenon of ionic intake since the interior of plant tissues is known to comprise a number of phases each of which may be in Donnan equilibrium with the external solution and under which circumstance product of the apparent internal ionic concentrations resulting from the total effect of all these phases is shown to be greater than the external product. Not entering into the relative

importance of these results and others each of which have their own limitations, it may be of use to remark that studies on the absorption of salts by plants grown on natural soils, particularly those yielding good crop, have important applications in investigation for determining the conditions for optimum growth by means of sand and water cultures; for while the amount of a given constituent absorbed does not necessarily indicate the quantity essential to proper development, fluctuations in the rate of absorption may be expected to reflect, at least to a certain extent, the nutritional peculiarities of the crop and serve as a guide in regulating the concentrations and amount of solutes at successive stages of growth.

6. DR. V. SUBRAHMANYAN, Bangalore.

*Influence of the soil on the absorption of salts by plants.*

I wish to confine my remarks to just one aspect of the subject which is important from the agricultural point of view, viz., the influence of soil on the availability of salts for plant nutrition.

A very large part of the literature on the subject of salt absorption relates to water-culture studies, but the results thus obtained, though fundamentally very important, are hardly applicable to field practice.

As an example of the above, one may cite the commoner experience with phosphates. Alkali phosphates, which are completely available in water cultures, are only very poorly so in the soil. This is due to the ready solubility of these salts in water and consequent interaction of the anion with the soil complex. The result is that the phosphate is rendered more or less unavailable in most types of soils. On the other hand, alkaline earth phosphates which are insoluble in water are very much more available than the alkali salts and continue to remain so for long periods. Thus, calcium phosphate does not react with the soil complex, but nevertheless is readily available to the plants. In a recent enquiry conducted at Bangalore, Srinivasan and Sadasivan have adduced evidence to show that calcium phosphate is solubilized by the plant in just the requisite quantities, so that very little surplus soluble phosphate is left over for interaction with the soil. Indeed, an elegant way of retaining the availability of soil phosphates is to convert them into calcium salts through basal dressings of caustic or carbonate lime. Another and an equally efficacious method of increasing the availability of phosphates in the soil is to apply soluble silicates. Srinivasan has recently shown that colloidal silica which is the first product combines *preferentially* with the mineral complex of the soil, thus releasing phosphate for plant nutrition.

Another direction in which the soil plays a very striking part is through interaction with metallic ions. A number of previous workers have shown that manganese salts, in even very minute quantities, have profound effect on water-cultured plants. This effect is essentially ionic and is directly traceable to the influence of the manganese ion. Beneficial effects are also observed in the soil, but then the manganese salts behave in an entirely different way. When applied in moderate quantities (say, 1-2 cwts. per acre), a soluble manganous salt is rendered insoluble almost immediately after addition to soil. The subsequent changes are of very considerable scientific as well as practical interest. Harihara Iyer and Rajagopalan working at Bangalore have shown that under normal conditions, the manganous salts are turned into manganese dioxide, which has a highly beneficial effect on crops. Oxidation of organic matter is hastened, thus releasing more food for plant nutrition. Biological activity is also stimulated. Increased yields ranging from 25–100 per cent. (depending on nature of crop) have actually been obtained. Even highly oxygenated compounds like permanganate first get reduced to manganese dioxide and then exercise a beneficial effect on plants. It would thus be seen that application of soluble manganese salts is an elegant

method of supplying the insoluble but nevertheless potent manganese dioxide to the soil.

The above observations do not entirely preclude ionic effects. It may, nevertheless, be pointed out that, in the case of tomato grown on soils with and without manganese salts, there was no significant difference in regard to their manganese contents. On the other hand, ragi grains (*Eleusine Coracana*) from manganese treated plots had a slightly darker colour than those from the control plots. We have yet no evidence to show how this effect is produced.

Soluble iron salts behave in a manner similar to the manganese salts. They get mostly converted into finely divided ferric oxide and thus facilitate oxidation changes in the soil. When applied in moderate quantities they also lead to increased crop production.

One rather interesting observation which has recently been made by Asana at Bangalore is that soluble ferrous salts are more beneficial than the corresponding ferric salts to water-cultured rice plants. The mechanism of the phenomenon is still not clear. It may be interesting to mention in this connection that in the manured swamp soil there is always some soluble ferrous iron in the early stages. This may be one of the beneficial effects of swamping which is so favourable to the rice plant. As already mentioned, the ferrous salts which result from the initial fermentation are subsequently converted into finely divided ferric oxide and thus exercise further beneficial effect on the plant.

7. Prof. A. H. R. Buller, Manitoba pointed out that so far as his experience went, the cell-wall did play a part in the absorption of salts by the plant cell.

8. Prof. V. H. Blackman, London, wound up the discussion laying stress on the all-important function of the protoplasm. As evidence he cited the fact that absorption was affected by the absence of oxygen.

## XXXII. THE SPECIES CONCEPT IN THE LIGHT OF CYTOLOGY AND GENETICS.

(*Sections of Botany, Zoology and Agriculture.*)

Prof. B. Sahni and later Prof. S. R. Bose presided, and Dr. (Miss) E. K. Janaki Ammal opened the discussion.

1. Dr. (Miss) E. K. Janaki Ammal, Coimbatore.

*Opening Remarks.*

It has been said that the test of the creed of a biologist is his definition of species. Though modern genetics has thrown considerable light on the nature of genetical differences between related species, at no time has it been more difficult to define species as at the present day. This is mainly because we now know more of the underlying causes of variation or discontinuity that exist between two forms than we did 20 years ago. These causes are now found to be different in the case of different species and genera.

The cyto-genetic analyses of plants and animals have shown that though the differences between some species are mainly gene differences, in others they are associated with changes in (1) the number, and (2) the structure of chromosomes. The discovery of plants with chromosome

numbers which are multiples of a basic number is so widespread that it has been observed in nearly every genus that has been examined critically. This discovery gives polyploidy a practical importance in tracing the phylogeny of species.

'Secondary pairing' of chromosomes at meiosis was first used by Darlington to interpret the history of the Pomoideæ.

By the synthesis of *Galeopsis tetrahit* from *G. pubescens* and *G. speciosa,* Muntzing was the first to show that Linnean species had arisen by hybridization and doubling of chromosomes. It is now known that many genera and species of cultivated plants are allo-polyploids. A number of artificially produced forms like *Primula kewensis, Nicotiana digluta* and *Digitalis mertonensis* have been produced by the same way, while 'amphidiploid' intergeneric hybrids like *Aegilotriticum* and *Raphano brassica* have been raised to the status of new genera.

The ease with which it is possible to hybridize widely differing genera in the family Gramineæ when factors that contributed to their isolation are removed, is shown by the many hybrids produced at Coimbatore between species of *Saccharum* and those of *Sorghum, Erianthus, Narenga, Bambusa* and *Imperata.*

'The indigenous canes of India, the so-called *S. barberi* and *S. sinense* of Jesweit occupy taxonomically a position intermediate between the noble cane *S. officinarum* and the wild species *S. spontaneum.* These latter represent a polyploid series ranging from $2n = 48$ to $2n = 80$ in India and $2n = 80$ to $2n = 124$ in Further India and E. Indies. In *S. barberi* and *S. sinense* aneuploid number ranging from $2n = 82$ to $2n = 124$ have been observed.

Evidence for the origin of *S. barberi* from *S. spontaneum* has been obtained from the study of occasional giant triploids with $2n = 84$ (triplopolyploids) which arose amongst selfed progenies of a *S. spontaneum* ($2n = 56$) in Coimbatore. These were found to be thicker and have more sugar than the type from which they arose and the resemblance to *S. barberi* was very pronounced. The occurrence of such giant triplopolyploids amongst intraspecific hybrids between the different chromosomal forms of *S. spontaneum* and the phenomenon of heterosis met with in crosses between widely separated forms of *S. spontaneum* seem to point out that hybridization must have played an important part in the evolution of the cultivated cane.'

### 2. Prof. R. Ruggles Gates, London.

On the gene theory variations arise, at any rate for the most part, in the chromosomes, and express themselves in ontogenetic development. An understanding of species and other categories of taxonomic classification must then ultimately be based upon an analysis of how chromosomes change. The conceptions associated with the terms linneons, jordanons, and syngameons have proved most useful in the genetic analysis of species and their variations.

From the cytological point of view we may classify chromosome changes as changes (1) in number, (2) in structure. Changes in number include: (*a*) polyploidy, so characteristic of plants, (*b*) polysomy, (*c*) fragmentation, (*d*) fusion of chromosomes. Structural changes include (*a*) segmental interchange, (*b*) duplication, (*c*) reversal, and (*d*) deletion of a portion of a chromosome. Some of these changes involve no immediate phenotypic change in the organism, but they serve as a basis on which future differentiation of type can take place.

Comparative cytology throws light on the processes by which these changes in number have taken place. The study of chromosome structure combined with comparative genetics shows how rearrangements within the chromosomes have been taking place. Examples are the location of parallel mutations in the chromosomes of *Drosophila melanogaster, D. pseudo-obscura, D. virilis* and other species; or the catenation of chromo-

somes in different *Oenothera* species. This appears to have come about through segmental interchange accompanied by genic mutations and followed by intercrossing. In all cases the ultimate raw material of evolution appears to be supplied mainly by genic mutations. The study of mutation rates and their natural methods of change may ultimately throw some further light on the origin of this 'raw material'. Different genera of plants and animals have specialized in different methods by which the genes thus produced are rearranged, multiplied or interlinked.

Many interspecific crosses both in plants and animals show that their differentiation has arisen through genic mutation. Examples, *Antirrhinum, Peromyscus.* In certain genera, e.g. *Oenothera*, there is evidence of cytoplasmic differentiation as well. Other types of cytological change come in to complicate the results by linking the genes in fresh groupings.

It was supposed until recently that interspecific sterility could only arise over a long period and had never occurred in experiment. Some biologists still regard it as an essential criterion of species. Intersterility is, however, no longer a sure guide even regarding nearness of relationship between types. We can now see in many cases how it has either arisen in experiment or must have arisen in the recent past. The numerous cases of amphidiploidy in plants and change in chromosome number or segmental reversal in various genera furnish such evidence. The natural selection of parallel mutations in species which have become intersterile, means evolutionary advance on a common front.

The genus *Oenothera* has evolved simultaneously chromosome catenation and small self-pollinating flowers. Under these conditions the seeds from each individual produce a pure line. Catenation preserves the advantages of heterosis. Occasional crosses occur, producing new types which again breed true. Thus the whole Onagra section of *Oenothera*, containing over 75 species, is a syngameon containing numerous linneons which occasionally intercross when dispersal brings them into contact. This, combined with gene mutations, produces a network of cross-related forms, linneons, jordanons and many smaller differences.

3. DR. C. D. DARLINGTON, London.

*The Integration of species.*

We are generally agreed that species arise, as Darwin said, by the selection of hereditary variations. We are not agreed as to how the selection takes place. It must depend on the nature of the variations that are available for selection. These are broadly of three kinds : changes in the internal properties, linear positions and quantitative proportions of the genes making up the chromosomes. These three must be selected so as to provide the means of isolation and adaptation. The comparison of species and the study of their hybrids show that the chromosomes are continually undergoing structural rearrangements which in various ways prevent crossing-over between the genes in the rearranged parts. These structural changes provide the means for holding together groups of genes and thus allowing for the preservation of good combinations. This is the first step in the integration of species. Structural changes also cause changes in the proportion or balance of the genes in the complement, thus adapting them to different environments. This is the second step in integration. Finally structural changes inhibit the pairing of the relatively changed chromosomes and lead to intersterility. This is the third step in integration. Where polyploidy is the agent of species formation the mechanism is different, but the three essential steps remain the same.

4. DR. E. W. ERLANSON, Budge Budge.

Genetics has helped to explain (*a*) variation within the species, and (*b*) parallelism in related species. The application of this improved

understanding resulted in the reduction of the number of American species of *Rosa* from 115 to 20. Cytology has thrown light on phylogeny and has solved some problems of phytogeography. We have finally broken away from the concept of a morphologically delimited species with a definite range and have adopted a three-dimensional fundamental unit the 'line of evolution' in both space and time for each species. It has been shown that interspecific relationship is a complex reticulum rather than dendritic. The unique cytological behaviour of the common *Caninæ* roses has distorted the perspective of some European workers who have persisted in the fallacy that modern diploid roses are descended from polyploid ancestors. This hypothesis is not necessary to explain the cytological conditions. The fact that the higher balanced polyploid rose species are both the most primitive morphologically and the most boreal in range has also been used to support the theory. The physiological effect of polyploidy is to increase cell size, slow down growth rate and increase adaptability. In *Rosa* the higher polyploids are physiologically best adapted for near arctic conditions. Their very polyploidy is a bar to further evolutionary progress, although as allopolyploids they may act as sources of new genes which appear in diploid descendants of hybrids between them and diploids. There are both generalized and specialized tetraploid rose types and tetraploids have arisen more than once on the American continent. The diploid *R. Woodsii* (near relative of the Eurasian *R. cinnamomea*) has the greatest north-south range of any rose. It is generalized and primitive morphologically and there is no reason to suppose that there have not always been diploid lines of descent in the genus which have given rise from time to time to the polyploids with which they still hybridize freely.

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